The Life Cycle Management and Intellectual Capital factors that influence sustainability integration in organisational processes

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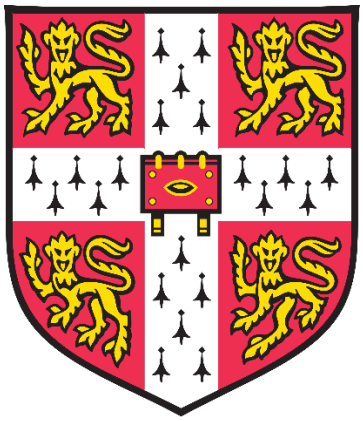

This dissertation is submitted for the degree of Doctor of Philosophy

November 2016

Institute for Manufacturing, Department of Engineering, University of Cambridge

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Abstract

Following the suggestions of the UNEP/SETAC Life Cycle Initiative publications on Life Cycle Management (LCM) as a business management approach to improve sustainability performance, this research explored LCM as a promising research area that could help identify the factors that influence the integration of sustainability aspects into organisational processes.

The initial research strategy was comprised of LCM literature analysis to explore LCM and identify potential factors that could direct the data collection.

The analysis of the LCM literature shows that LCM is vaguely described. This research analysis puts into context the various LCM approaches through the introduction of the four LCM elements. The LCM elements were used as a frame to analyse the LCM cases found in the literature and identify the factors that influence integration of sustainability in organisational processes.

The next stage of the research strategy was to conduct action research studies to explore in close proximity the integration of sustainability aspects in organisational processes. Two in depth action research studies were conducted, influenced by engaged scholarship.

During Case A, the LCM elements were used in practice to influence the project whilst the LCM factors were observed in practice. Case A demonstrated the complexity of sustainability-related information integration in organisational processes and the division of information flows towards different organisational functions to inform their own decision. The analysis highlighted that developing knowledge is a key LCM factor that influences the application of LCM.

As the importance of developing knowledge became apparent, a novel sustainability related intellectual capital (SrIC) framework was developed then used during Case B. This framework is shown to assist the sustainability professionals of Company B in enhancing the sustainability related intellectual capital of the company, which in turn led to more effective sustainability integration.

This research used LCM as a 'vehicle' to explore the integration of sustainability aspects into organisational processes and hence contribute to the LCM literature with the four LCM elements framework of analysis, descriptions of the factors that influence the application of LCM, bringing a focus on the importance of developing knowledge for the effective application of LCM, and identifying the intellectual capital factors that influence the integration of sustainability aspects into organisational processes.

Declaration

I declare that this thesis is substantially my own work and no part of the dissertation has been previously submitted to any university for any degree, diploma or other qualification. Previously published work by the author in the form of conference proceedings is drawn on for parts of this thesis. When reference is made to the work of others the extent to which that work has been used is indicated in the text and the reference.

This document contains 71,477 words, 55 tables and 74 figures, and therefore adheres to the limits of 71,500 words (10% words extension was granted to the 65,000 words limit), 150 tables and figures, and an attached DVD with additional material put forth by the Degree Committee of the Department of Engineering.

Ioannis Mastoris
Cambridge, November 2016.

Acknowledgements

The completion of this research could not have been possible without the support and assistance of many people and organisations that had a significant role. The author would like to express his appreciation and gratitude to the following.

I would like to express my gratitude to the EPSRC Centre for Innovative Manufacturing in Industrial Sustainability for all the financial support they provided. The information collected from the industrial partners was one of the core aspects of this research. Therefore, I would like to express my gratitude to all the industrial collaborators who contributed to this research and especially to the partners from two industrial organisations that I had the honor to use in my main case studies.

PhD is not a short journey and I was blessed to be part of the research centre with wonderful and supportive people. I would like to thank all the administrative, academic and research staff of the centre. I would also like to thank my very good friends for their support and their friendship. Thank you, Ergun, Lambros, Lloyd, Miying, Sotirios, Sudhir and Yuan. Sotirios our bbqs and discussions were the best part of my social life during this period. In addition, I would like to thank Dr Dai Morgan for being my PhD coach for the first two years of my research. I consider myself truly lucky to be supervised by Professor Steve Evans. Steve believed in me and allowed me to conduct my research at Cambridge. Except for being an amazing supervisor, he became a wonderful and supportive friend and mentor. I will always be thankful that I met Steve. Moreover, I would like to thank my advisor Dr Claire Barlow.

Through this tough process I was privileged to have old and new friends next to me. Maik, Tina and Dorotheos, thank you very much for your endless love and support all these years. Whenever I needed you, you were next to me. I am so fortunate to be my friends. During the PhD time, I was truly lucky to meet and become friends with Anel, Eve, Frieder, Georgios[2], Julia and Katerina. Thank you very much for your support. In addition, I would like to thank Eve for her help with the transcripts and Anel for proofreading my thesis.

I would like also to Thank Dr Theodoros Markis and Dr Ioannis Paravantis that were the first academics that believed in my abilities and through their coaching showed me the way to progress and explore the world.

Friends can be close to your heart; however, family is in your heart. There are no words to express my gratitude to my family. I am so grateful to have them next to me providing their love and support in good and bad times.

In life, unexpected things can happen that make you see life from another perspective. When I started my PhD, I was sick and I did not know it, but I am finishing my research healthy. I would like to thank all my friends who were next to me through this challenging time. In addition, I would like to thank the staff of Huntingdon surgery, Addenbrookes and Papworth hospitals for taking good care of me. Special thanks go to Dr Philippa Evans, Dr Vasillis Vasiliou, Dr James Rudd and Mr Steven Tsui.

I would like to dedicate this thesis to my parents who brought me into this world and Mr Steven Tsui who did his best to help me stay around for longer.

Contents

List of Figures

List of Tables

Abbreviations

3Ps: Product – production Process – Place layers

4Ps: People – Product – production Process – Place layers

4th P: People layer

AR: Action Research

BAT: Best Available Technique

BOM: Bill of Materials

BU: Business Unit

CG: Corporate Group

CI: Continuous Improvement

CIS: Centre for Industrial Sustainability

CMSG: Country Management Sustainability Group

CO2: carbon dioxide

CR: Corporate Responsibility

CSR: Corporate Social Responsibility

DIK: Data – Information – Knowledge

DIKA: Data – Information – Knowledge – knowledge to Action

DM: Directly Measured

EHS: Environment Health and Safety

ELCA: Environmental Life Cycle Assessment

EMEA: Europe, Middle East and Africa

EMS: Environmental Management System

EoL: End of Life

EPD: Environmental Product Declaration

ES: Engaged Scholarship

EU: European Union

FSC: Forest Stewardship Council

GF: Group Function

GHG: Green House Gases

GMSG: Global Management Sustainability Group

H&S: Health & Safety

HR: Human Resources

IC: Intellectual Capital

ICM: Integrate Chain Management

IIRC: International Integrated Reporting Council

ILCD: International reference Life Cycle Data system

Inter-organisational: relations of an organisational with external actors

Intra-group: relations inside an organisational group

Intra-organisational: relations among organisational groups

IPP: Integrate Product Policy

ISO: International Standards Organization

KD: Knowledge Development

KM: Knowledge Management

KPIs: Key Performance Indicators

LBU: Local Business Unit

LC: Life Cycle

LCA: Life Cycle Assessment

LCC: Life Cycle Costing

LCSA: Life Cycle Sustainability Assessment

LCT: Life Cycle Thinking

LDSM: Local Division Sustainability Manager

LSM(LBU): Local Sustainability Manager for Local Business Unit

LSM(LG): Local Sustainability Manager for Local Group

ME: Marker Efficiency

NGO: Non Governmental Oorganization

NPV: Net Present Value

NU: academic institution specialised in fashion design

OECD: Organization for Economic Cooperation and Development

OHSAS: Occupational Health and Safety Assessment Series

PD: Product Development

PDCA: Plan–Do–Check–Act

Ph.D.: Philosophy Diploma

PLM: Producy Llifecycle Management

PM: Product Marketing

POEMS: Product Oriented Environmental Management System

PSI: Product Sustainability Index

PwC: PricewaterhouseCoopers

R&D: Research & Development

RoI: Return of Investment

S: Sourcing

SAC: Sustainable Apparel Coalitation

SAP: Sustainable Apparel Programme

SCM: Supply Chain Management

SECI: Socialization–Externalization–Combination–Internalization

SETAC: Society of Environmental Toxicology and Chemistry

SG: Sustainability Group

SLCA: Social Life Cycle Assessment

SME: Small and Medium Enterprises

SrCC: Sustainability related Cultural Capital

SrHC: Sustainability related Human Capital

SrIC: Sustainability related Intellectual Capital

TBL: Tripple Bottom Line

TQM: Total Quality Management

UNEP: United Nations Environmental Program

US: United States

USEPA: US Environmental Protection Agency

VC: Value Chain

Definitions

Blankspots: areas in the LC with missing information that can be divided into two categories, including minor [low influence] and major [potentially of high influence].

Corporate LC: the lifetime development of a corporation.

Data: a form of facts description in a disconnected and objective way. Data are unprocessed facts that in their current form cannot support judgement, cannot point to the importance or relevance of facts and cannot be used to make suggestions or conclusions (Davenport and Prusak, 2000).

Decision making: the process by which one or more organizational units make a decision on behalf of the organization (Huber, 1980).

Decision: action purposely chosen from a set of alternatives to achieve organizational or managerial objectives or goals.

Definition: statement of exact meaning of a concept that is true in every case.

Departments: organisational group with a specific organisational task.

Description: a more detailed (compared to definition) meaning of a concept that can change from case to case.

Due diligence: comprehensive, proactive process to identify the actual and potential negative social, environmental and economic impacts of an organization's decisions and activities over the entire life cycle of a project or organizational activity, with the aim of avoiding and mitigating negative impacts (ISO, 2010).

Elements: an essential or characteristic part of something abstract.

Factors: circumstances that influence a result.

Framework: a system of rules, ideas, or beliefs that is used to plan or make a decision.

Function: organisantional group with a specific organisational task.

Group: a number of organisational staff that cooperate to deliver a specific organisational task.

Hotspots: identified and prominent negative impacts.

Information flow: transmission of information from a sender to a receiver.

Information: the outcome of specific facts or data processing that aims to raise the understanding of data relations and offer a structure that will help draw conclusions at a later stage (who, what, where, when) (Cleveland, 1982; Ackoff, 1989).

Integration factors: characteristics of the mechanism that needs to be in place to integrate sustainability aspects in organisational processes.

Intellectual Capital: the knowledge and routines embedded in the employees of a company. Smith and Parr (1994) defined this as 'what walks out of the door at the end of the day'.

Inter-organisational: between different organisations.

Intra-group: between different members of the same organisational group.

Intra-organisational: between different groups of the same organisation.

Knowledge in Action: the use of obtained knowledge to improve strategy, decisions, etc.

Knowledge: a synthesis of framed, values, contextual information, intuition and expert insight that originates and is applied in the mind of knowers, and help them evaluate and incorporate new experiences and information. (Davenport and Prusak, 2000).

Manufacturing processes tree: sequence of manufacturing processes from raw material to product formation.

Marker efficiency: material efficiency of each fabric during the fabric cutting process. It is the prcentage of the fabric panel that is used in the final product.

Objective: a performance aim for a person or system.

Organisational group/function: type of organizational structure in which the organization is divided into smaller groups based on specialized functional areas

Organisational level: an hierarchical level distinction in an organisation.

Paradigms: basic belief systems based on ontological, epistemological and methodological assumptions.

Product lifecycle: the processes from raw materials formation to the EoL of the product.

Product market lifecycle: the time that a type/model product is active in the market.

Project: an individual or collaborative effort that is carefully planned to achieve a particular aim.

Sustainability aspects: the set of chosen sustainability challenges that a company works on; (noting that sustainability is a multifaceted challenge and each company works on different aspects).

System: established organisational processes.

Teams: different groups that cooperate to achieve a result.

Technology: the use of scientific knowledge or processes in business, industry, manufacturing, etc. (Cambridge University Press, 2011).

Units: organisantional group with a specific organisational task.

Value chain: All the value interactions across product's lifecycle.

1. Introduction

This chapter introduces the research trigger and research problem, states the research aims and goals. At the end of this chapter the author will provide the structure of the thesis.

1.1. Sustainable development and business

There is a strong link between the way businesses tackle sustainable development and the sustainability state of our societies.

Sustainable development calls for a balance of three systems: natural, economic and societal (McElroy and van Engelen, 2013). These three systems are interrelated, though they have different characteristics:

- The natural system is a closed system (White et al., 1998) that contains limited resources and provides services from fragile ecosystems.
- The economic system is an open system that utilises the natural system and offers services to the societal system (Victor, 2008). The economic system provides ways of allocating the services in the society (Boettke, 2014) and potentially the management of the natural system.
- The societal system is a dynamic system that relies on the natural system for its survival (White et al., 1998).

The impact of the societal system over natural has begun to have a significant influence at a global level (Zalasiewicz, Williams, Steffen and Crutzen, 2010). Ehrlich and Holdren (1971) factored this impact as a product of:

- Population as a societal factor: the larger the population, the more natural capital is used (Chertow, 2000; Mulder, 2006).
- Affluence as an economic factor. It refers to consuming power of the society, the larger the affluence, the more consumption of resources (Chertow, 2000; Mulder, 2006).
- Technology which sets the efficiency rate of natural system use. It is the amount of resource used and waste generated for the utilisation of the natural system to cover the needs of the societal system (Chertow, 2000; Mulder, 2006).

Technology is a catalyst that can tip the balance in all three systems. Technology can increase productivity and the consumption of resources, and thus boost population; it can increase efficiency and have the same outcome with fewer resources. Technology is defined as: '*the use of scientific knowledge or processes in business, industry, manufacturing, etc.'* (Cambridge University Press, 2011). Technology is not only confined to machinery, but also includes management practice (Bloom et al., 2016).

Senge et al. (2010) support the view that business is the cornerstone of modern societies and the realisation of sustainable development by businesses will enormously improve the balance of the three systems. Structural changes can be imposed at the macro level by harnessing entrepreneurship, and technological and organisational change in microeconomic systems, i.e. businesses (Gouldson and Murhy, 1997).

According to Mulder (2006), business decisions largely impact society and this, in combination with political action, allows us to mobilise companies in addressing sustainable development. According to Mulder (2006) and Weybrecht (2013), businesses can:

- invest in more efficient technology that reduces the pressure to the natural system,
- pose new business models that aim at providing the service to the customers instead of the product (economic system), and
- educate customers on having a more sustainable lifestyle (societal system).

1.2. Problem statement

The way that business integrates sustainability aspects in corporate processes is often unstructured. The lack of methods to assist this integration prevents business from unlocking its sustainability potential.

Epstein and Buhovac (2014) comment that businesses have become more sensitive to their sustainability performance and are striving to become better corporate citizens. According to the authors: *'As companies search for ways to improve their performance, determining the best ways to thoroughly integrate these improvements into all parts of the organisation still present challenges. These challenges are because implementing sustainability is fundamentally different than implementing other strategies in the organisation'*. The management of this inconsistency creates challenges with the authors suggesting that

financial initiatives being linked to clear, measurable, and short-term metrics is causal; while sustainability often relates to uncertain and long-term measurements (Epstein and Buhovac, 2014).

Labuschagne and Brent (2005) stated that the challenge for business to adopt sustainability could be explained by three levels of change requiring implementation: the strategic, the business processes and the operational (Figure 1). The analysis of the data presented in Figure 1 is a product of Labuschagne's and Brent's work; the raw data is based on the results of the PwC (2002) corporate sustainability survey on senior executives and managers from 140 companies. Labuschagne and Brent (2005) suggested that there is a gap between strategic and operational levels; these researchers believe that companies are active on what they term the strategy level, but they do not have a way to systematically integrate sustainability aspects.

The statistics of sustainability-related actions that appeared in the companies surveyed are mentioned in Figure 1. There is evidence that there are variable actions at the strategy and operations level: businesses adopt sustainability principles into their culture, endorse international agreements, implement environmental management systems and publish sustainability reports, etc. However, this is not the case for the businesses processes and methodologies level that does not efficiently take environmental and social issues into account. This highlights the need for overall sustainability to better focus on business processes and methodologies that include sustainability within organisational processes.

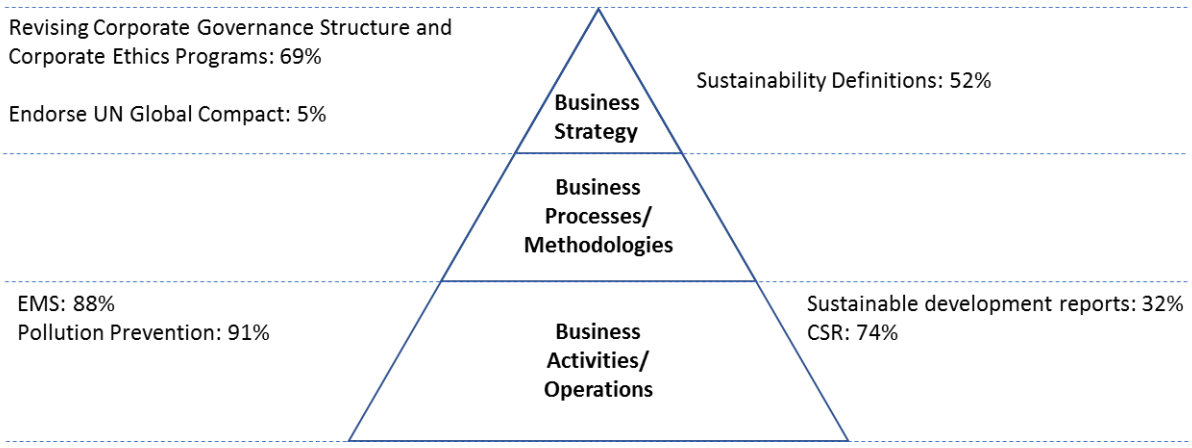


Figure 1. Incorporation of sustainability within different levels in organisations (Labuschange and Brent, 2005).

'The business processes and methodologies (level) largely ignores environmental and social sustainability aspects.' (Labuschagne and Brent 2005). The term '*business processes and*

methodologies level' is not described well by Labuschagne and Brent (2005) and it can allow misconceptions. The *'business processes'* part can be linked to business growth that focuses business results and the *'business methodologies'* part can be related to organisational development (Crabb, 2014). The statistics in Figure 1 helped to come to the conclusion that the focus is on the processes that integrate sustainability in organisational processes. As the researchers focused only on the organisational aspect, in the rest of this thesis, this level will be called *'organisational processes level'*.

However, except Labuschagne and Brent (2005), there are emerging academic studies that have explored the integration of sustainability using strategic management lenses, such as:

- Gladwin et al. (1995) mentioned that the usual approaches of incorporating sustainability are not effective ('limits their potential to implement'), therefore, there is a need to align business methodologies with the principles of sustainable development.
- Lozano (2012) linked the sixteen different types of corporate sustainability initiatives identified in the sustainability literature with five corporate systems elements (i.e. operations and production, management and strategy, organisational systems, procurement and marketing, and assessment and communication). The organisational systems element had the least links as they were limitedly represented in only two sustainability initiatives.
- Engert et al. (2016) explored the integration of sustainability from the perspective of strategic management. They analysed 114 papers in their research. They describe corporate sustainability as an integrated part of the business strategy and processes. However, the majority of the case companies limit their focus at the operations level instead of integrating sustainability at all business levels. The authors highlight the need for empirical research in this research field as they state that integration of sustainability to strategic management has failed.
    - Krechovska and Prochazkova (2014) empirical research agree with Engert et al. (2016) that sustainability is not integrated into individual business processes. The authors support the finding that companies usually carry out activities, but often in isolation and they are not integrated into the business processes.

- Smith and Offodie (2015) analysis of three case studies also agrees with Engert et al. (2016) that the tactical level of sustainability is not truly integrated in the organisation.

  Here they use the term tactical management instead of business processes. According to Brent (2011) the term tactical refers to medium-term decisions while strategic to long-term.

- Grewatsch and Kleindienst (2015) provide a literature analysis on the interaction between corporate sustainability and corporate financial performance and try to identify the moderators and mediators of this relation. They indicate the existence of implicit argument occurring between functions that points to the absence of an explicit moderator and/or mediator to make this relation effective.

- Baumgartner (2014) discusses the lack of a comprehensive and integrated view on corporate sustainability and offers the view that to overcome the absence three layers need to be addressed – and can be linked with Labuschagne and Brent (2005) organisational levels. The normative layer that focuses on enhancing the legitimacy of corporate activities by stakeholders and society; the strategic management layer that ensures the effectiveness of corporate sustainability; and the operational management layer that focuses on the efficiency of implementation. In addition, Baumgartner and Rauter (2017) links the strategic management effectiveness with the (organisational/business/tactical) processes dimension to develop a sustainable organisation.

However, there are also emerging non-peer reviewed studies such as Epstein (1996), Weybrecht (2011), Grayson (2012), McElroy and van Engelen (2013), Epstein and Buhovac (2014), and van Tulder et al. (2014) that point to specific challenges that either mostly focus on strategy or operational level issues without seeing sustainability as an organisational issue that needs to be addressed at all three levels. The focus at the organisational processes level is limited, except Doppelt (2010) that provides some change management factors.

Except academic literature, information on the weak connection between strategy and operations comes from the grey literature of management consulting. This is not unusual for rapidly developing practices and problems, as management consultants work very closely

with organisations and identify areas of inefficiency that academia can pick up to analyse and provide solutions.

Bonini as the main researcher on sustainability at McKinsey and Company provides information on the 2011 (2956 executives participated) and 2014 (3344 executives participated) sustainability surveys. They state that actions at the operational level are disconnected from the strategy level with their main conclusion being that businesses will have to take a strategic approach to sustainability and embed it into their value creation levers, while taking into consideration that each company is a unique case, and therefore the pathway to sustainability will be unique too. Bonini and Gorner (2012) state that many businesses launch ad hoc initiatives to meet stakeholders' demands rather than facing sustainability as a challenge with direct impact on the business results. That brings them to a position of struggling to manage and execute their sustainability initiatives and having far to go to deliver them (Bonini and Swartz, 2014; McKinsey and Company, 2014). It is also mentioned that sustainability is continuously growing as a core business issue. However, there are challenges on capturing its full value (McKinsey and Company, 2014). Even, the PwC 17th annual global CEO survey (1344 companies in 68 countries) closes by wondering: 'Sustainability – is business equipped to change?' which suggests that business processes are not designed to deal with sustainability challenges yet (PwC, 2014).

During the early parts of this study most of the pier-reviewed literature mentioned above was not available and non-pier reviewed and grey literature was the main source of evidence in grounding the research problem. Later this claim was also backed by academic literature that seem to confirm that companies have a problem with the poor connection between strategy and operational levels, and subsequently, unlocking their sustainability potential. It seems that companies do not have an organised way of engaging with enhancing sustainability performance and often act spasmodically when they have to show that they work on it.

Up to this point, the language of the literature is used, which the researcher believes identifies a really important problem in practice, but lacks precision.

Statement of research problem: ***There is an absence of method(s) that can help integrate sustainability into organisational processes.***

1.3. Research direction

The direction of this research is on understanding if Life Cycle Management (LCM) is a solution to the research problem. LCM is introduced as a promising approach that could help business address the organisational processes level methodological gap.

The United Nations Environmental Program (UNEP) and the Society of Environmental Toxicology and Chemistry (SETAC) set an initiative back in 2001 (Sonnemann et al., 2001) on business and sustainability with a working group that proposes Life Cycle Management (LCM) as a business management approach to improve the sustainability performance of companies and associated value chains (UNEP/SETAC, 2009). The UNEP/SETAC Life Cycle Initiative has published some reports providing LCM guidelines for business. The UNEP/SETAC society thinks that LCM is a conceptual framework that fill the methodological level gap, as described in Figure 1. The researcher is interested in studying LCM's potential rather than agreeing.

According to Labuschagne and Brent (2005) and Nilsson-Lindem (2014), LCM is seen as having the potential to solve the problem of better integrating strategic and operational management. They argue vaguely but strongly for the potential of LCM, and the researcher feels that this instinctive feel for a solution is worthy of further study.

1.4. Lifecycle Management (LCM) and business sustainability

What LCM is and how it can impact business sustainability is discussed.

'Lifecycle management is an extremely powerful concept and process and can enable businesses and other organisations to make sustainability part of "business as usual" and deliver real-world improvements for them and their customers.' (Rebitzer, 2015).

Klein et al. (2013) characterises LCM as a complex field with an insufficient knowledge infrastructure that often prevents to benefit from its innovative topics and issues. Balkau and Sonnemann (2010) provide the following high-level description of the foundations and principles of LCM. According to them, LCM is an umbrella framework for combining and applying other management instruments in a more holistic life-chain perspective to connect the various stakeholders and effectuate local and system-level improvements. LCM has three broad categories of 'owners':

a) individual companies that aim for a holistic form of sustainability management,

b) government policies and regulations that aim to address system dysfunctions or to deal with certain product issues using a life cycle approach, and

c) multi-stakeholder collaboration to manage sustainability issues for selected commodity materials and products.

The focus of this research is focused on LCM for individual companies considering the synergies with the other LCM 'owners'. The researcher considers LCM as a potentially powerful conceptual framework that could help manage the integration of sustainability aspects in organisational processes. LCM is proposed as offering companies a logical structure to integrate environmental and social information from across the product lifecycle in their decision-making. The researcher is interested in studying LCM's potential rather than agreeing.

Management theories are based on a fractured epistemology that constitutes only a part of reality. This has resulted in organisational theories that neglect to consider their impacts on the natural and societal systems and act like these systems are interacting with them (Gladwin et al., 1995). According to Bonini and Swartz (2014), and Epstein and Buhovac (2014) this has changed for a number of companies. For some companies, considering and enhancing sustainability performance is a customer demand. For others it is a specific demand posed by stakeholders, and for still others it is a strategic imperative, especially those that are active in resource-constrained areas. Ehrenfeld (2004) has described this practice as an attempt to reduce unsustainability rather creating sustainability.

According to Remmen and Thrane (2007), the purpose of LCM is: *'to strengthen the environmental, social and economic performance in companies, through an integrated effort across departments as well as among the stakeholders in the product chain. In this perspective, LCM is an overall business strategy for an enterprise to:*

- *Strengthen the commitment towards sustainable development.*
- *Increase the co-operation between departments in a company.*
- *Enhance the collaboration in the product chain and with external stakeholders.'*

1.5. Research aim

The aim of this research is to provide a better understanding and to identify the factors for integrating sustainability at the organisational processes level. The factors are characteristics of the mechanisms that better integrate sustainability aspects in organisational processes.

The research problem that the researcher is interested in is at the leading edge in the field, as more is known in practice than academia. The author believes that working close to practice to try to solve such problems is more revealing and the research will be conducted as close to practice as possible. As there is not any available framework, the researcher also expects to build a conceptual framework that could be used as a research tool within the study.

The goals of this research are:

a) to better understand through observation how companies currently integrate corporate sustainability across the strategy and operations gap, exploring by identifying the factors of integration at the organisational processes level.

b) to understand how LCM might contribute to the gap reduction.

1.6. Research context

This Ph.D. study was funded by and carried out in the context of the EPSRC Centre for Industrial Sustainability. To deliver this project, the researcher not only participated in numerous projects related to the Centre but fostered collaboration with external organisations when additional data was needed.

1.7. Research flow

The research proceeded in five iterative steps as described in Figure 2. The research flow between these five steps was not linear. The red arrows show the actual research flow and the blue arrow reflect the research synthesis flow.

In the beginning, a research problem was identified as described in this chapter. Then the problem was situated through background review and formulation of the research problem. To achieve that a thorough review of the lifecycle management (LCM) literature was conducted (Lit. 1).

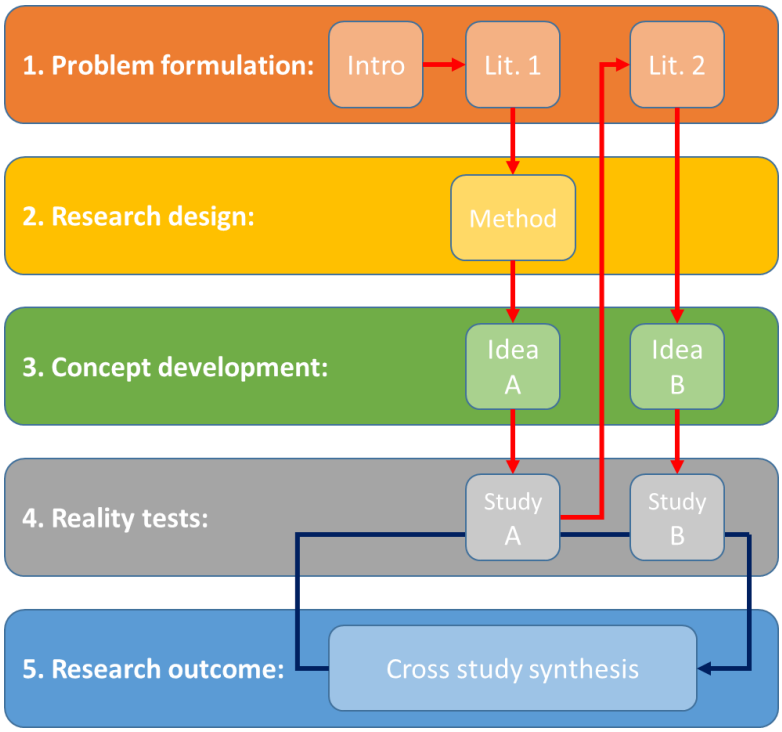


Figure 2. Research flow.

The LCM literature analysis provided a better understanding of the problem and determined the direction that this research should take, helping to formulate the research question and subsequently develop the research method (Method).

The LCM literature helped the researcher to develop ideas on the way LCM could be conducted, and sustainability information could be analysed by companies (Idea A).

The first action research case was then conducted. This study provided a better understanding of the problem (Case A).

Case A analysis encouraged the researcher to deepen the focus of his research on the factors and processes that seemed more important than others and explored the literature on knowledge management and intellectual capital to better study the way companies integrate sustainability aspects in organisational processes (Lit. 2).

The absence of a framework on the relation between intellectual capital and sustainability-related processes of an organisation, and the experience from the first study led the researcher to create a conceptual framework (Idea B).

With a conceptual framework/factors to test, the researcher conducted Case B.

At the end of Case B, a cross-case synthesis and review was conducted. The contributions to knowledge of this research emerged, and the conclusions were made (Cross-case analysis).

2. Literature review on lifecycle management (LCM)

This chapter grounds the research in the literature. Gaps in existing knowledge are addressed to form the basis for this research inquiry.

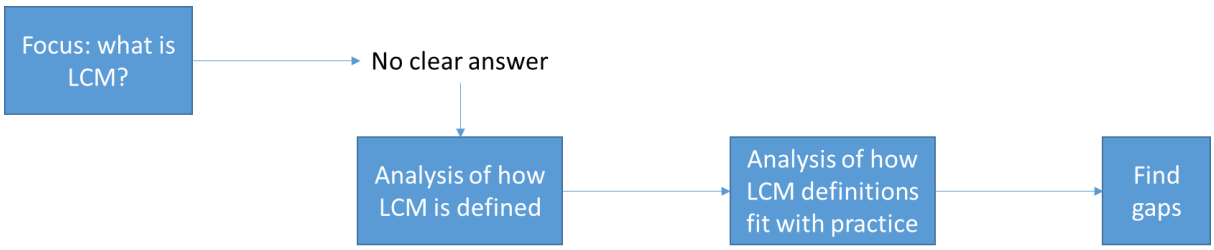


Figure 3. Literature review flow.

As mentioned in Chapter 1, LCM will be explored as an organisational processes level methodological approach to support the integration of sustainability aspects. The researcher decided to focus on what is LCM, but from the first step understood that there is not a clear answer to that question. This triggered the researcher to conduct an analysis of how is LCM defined in theory and how this compares with practice to identify the gaps of the current definitions. The author believed that in this way, by the end of this chapter would have a sound understanding of what is known and what needs to be known to use LCM as a method to integrate sustainability aspects.

2.1. Literature review flow and method

This literature review adopts a hybrid technique in developing an LCM literature base, the aim is to systematically review the academic literature and explore the available knowledge on LCM.

2.1.1. LCM literature base

LCM is a topic that is still under development, therefore, the researcher decided to follow a hybrid literature flow by combining elements of systematic literature review (SLR) that provided a starting point for identifying references and structure the analysis, and snowballing to enhance the reference base as there are lots of interesting references across a broader literature, including SLR research references and publications of well-known LCM researchers. The LCM literature base formation is described in Figure 4.

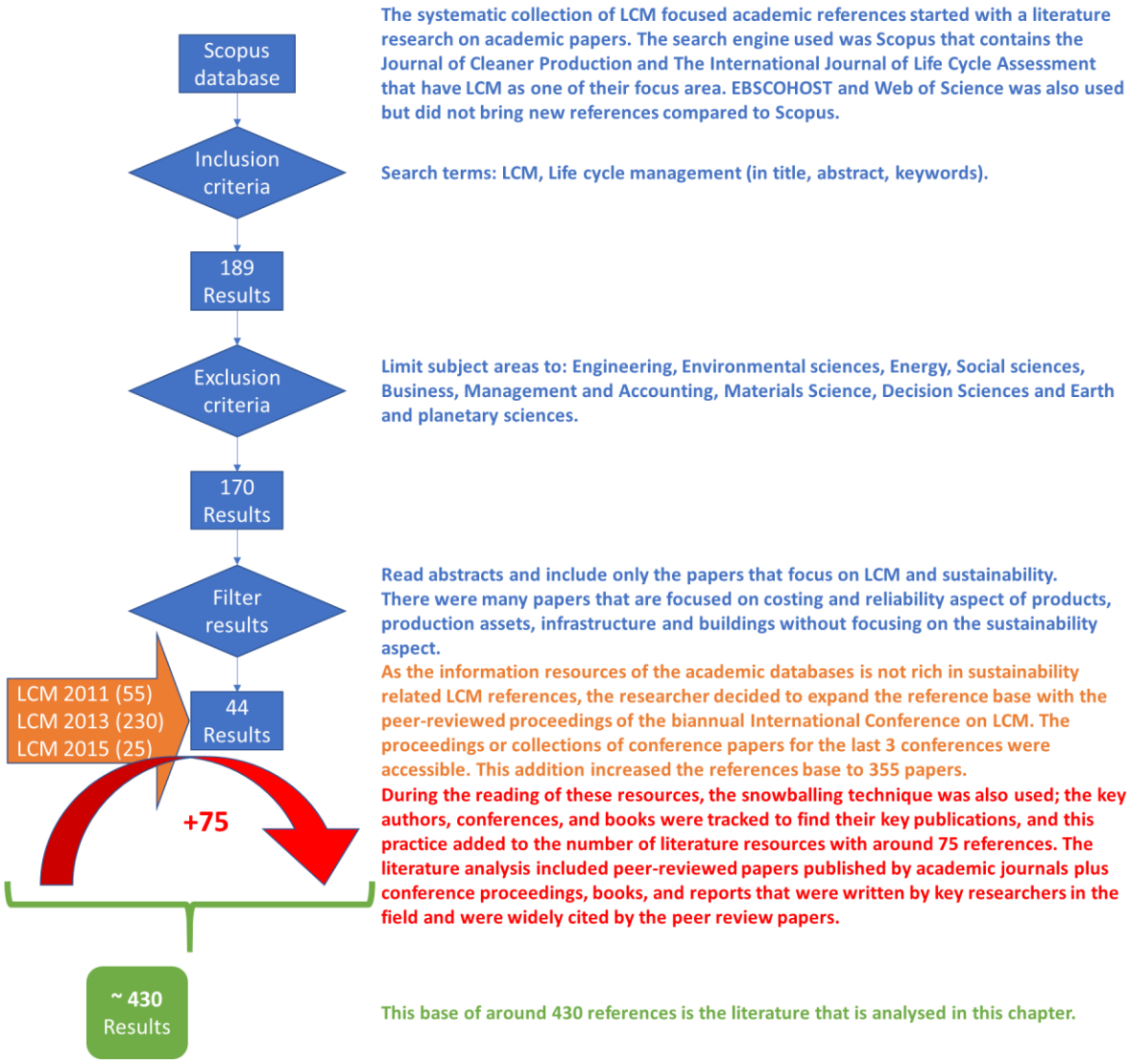


Figure 4. LCM literature base formation diagram.

Snowballing allows the researcher to include interesting references and not limit creativity and intuition (Easterby-Smith et al., 2012). One weakness of snowballing is that the criteria for filtering papers might be biased due to the researcher's personal research preferences. Also, some relevant papers may be omitted if they are not cited by any of the papers in the literature database (Nutley et al., 2002); this was addressed through SLR. However, these weaknesses also appear when other methods are used. To mitigate for these weaknesses and to ensure comprehensiveness and impartiality of the literature review, the researcher kept up to date with research in the field, discussed his work frequently with other researchers and followed relevant publications.

2.1.2. LCM literature analysis

This literature review as described in Figure 5 has three interconnected analysis levels.

The first level was focused on the LCM definitions and descriptions found in the LCM literature. In the beginning, the focus was on the definitions list provided by Saur et al. (2003) and Poikkimaki (2005). In both lists the researcher realised that the given definitions were not written following the same principles. Most of the given definitions [‘a statement of exact meaning of a concept that is true in every case’ (Oxford dictionary,2016)] could be clustered as descriptions [‘a more detailed (compared to definition) meaning of a concept that can change from case to case’ (Oxford dictionary, 2016)]. The descriptions specify conditions were the definitions can be applied (intensional/extensional). Based on that the researcher scanned the LCM literature base for LCM definitions and descriptions. The result of the analysis of the many definitions and descriptions was the identification of four elements that help structure the analysis of LCM. The four LCM elements along with the LCM concepts [‘an abstract idea that attempts to describe a phenomenon’(Oxford dictionary, 2016)] and cases [‘a record of research on concepts use’ (Oxford dictionary, 2016)] identified in the LCM literature base were the inputs to the second level. The four elements were used successfully to analyse the concepts and cases; this development demonstrated the validity of the four LCM elements identified in level one. Nevertheless, throughout the case analyses the researcher noticed the existence of managerial processes/practices that guided the four LCM elements progress. The analysis of these processes/practices to identify the guiding factors was the task of the third level.

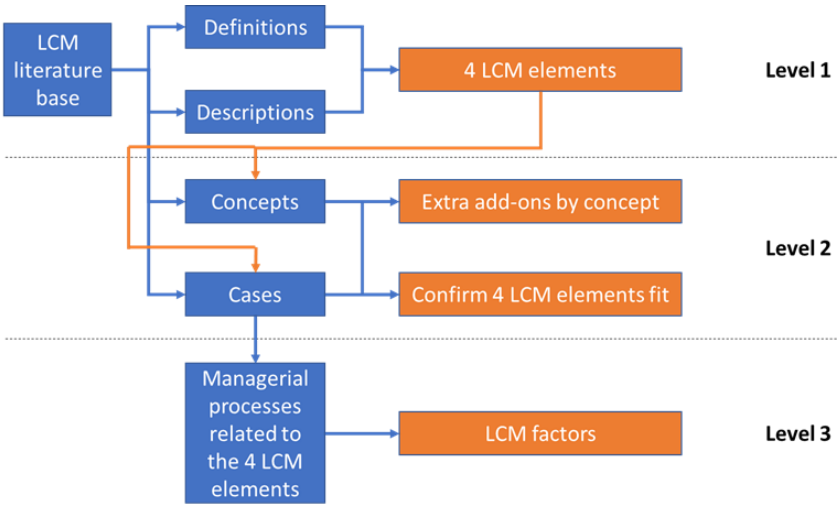


Figure 5. LCM literature flows and levels.

The literature analysis was based on the five steps described in the rows of Table 1. For definitions, descriptions and cases, the text that related to that type of analysis was extracted for analysis. Then, certain thematic groups that where called clusters were developed. In all five analyses, the words and phrases that characterise/ relate to each cluster were marked. In the following step, these words/phrases were analysed and in the last step the patterns were identified.

Table 1. Analysis steps used across the literature analysis.

	Definitions	Descriptions	Concepts	Cases	Managerial processes
Extract text	v	v			v
Develop thematic groups	v	v			v
Highlight cluster words/phrases	v	v	v	v	v
Analyse/characterise words	v	v	v	v	v
Identify patterns	v	v	v	v	v

2.2. Exploring LCM

LCM is not a precise term: variable definitions exist, there are multiple descriptions and concepts. However, the majority of authors consider LCM as sustainability-related action(s) of a corporation. In this section, the researcher will introduce a framework that will help in the analysis of literature.

In 1992, the Organisation for Economic Cooperation and Development (OECD) mentioned LCM for the first time to describe the development of sustainable product policies (OECD, 1994). The OECD paper examined environmental lifecycle approaches and the implication for international trade; and originally the LCM research was tied to the OECD programs for eco-labelling, eco-packaging and recycling (OECD, 1994). OECD aligned LCM with the 'cradle to cradle' approach while the policy makers used the term LCM when addressing products' lifecycle impacts.

Soon after, Linnanen et al. (1995) conducted research on LCM as an integrated approach towards corporate environmental issues and provided the first definition of LCM in the context of environmental management. In the following years, UNEP/SETAC Lifecycle Initiative, an LCM working group, tried to develop LCM further (Saur et al., 2003), focusing on

all three abovementioned directions (i.e. policy, corporate management, and product lifecycle performance).

Today organisations and researchers apply Lifecycle Management as a sustainability term for quite different sustainability facets through time. However, LCM is still a concept under development (Mazijn and Revéret, 2015). This combination of an evolving and multifaceted concept does not allow to provide a common understanding regarding the current meaning of LCM. Below are some comments from researchers who reviewed LCM literature in the past:

'The relation between the concept and the tools, however, is not well established and deserves a thorough and critical discussion. … At a closer look, however, it seems that each group uses its own approach and mixture of methods and it is not always clear how well the methods taken out of the tool box are tuned in or fit together' (Klopffer and Heinrich, 2002).

'According to the vague definitions, almost any environment-related activities could be called LCM' (Poikkimaki, 2006).

'The LCM definitions found in the literature are vague' (Jensen and Remmen, 2006).

'There are various and vague aspects included in the concept of LCM, so a specific definition will not be able to touch upon each of the various aspects' (Remmen and Thrane, 2007).

'There is a need to clarify this term (LCM) and its definition more than a decade since the concept was first introduced. … The definitions of LCM are thus wide and its concept needs further development' (Sonnemann et al., 2015).

The abovementioned quotes call for an academic community that currently works on an overly loosely defined concept to deepen its study of LCM's definition and hence benefit the LCM community.

In the following section, the researcher is going to explore *the concept of LCM* mainly from the perspective of corporate sustainability management. This section will cover definitions, descriptions, concepts, and corporate case studies mentioned in the literature.

2.2.1. LCM elements

Multiple descriptions and definitions of LCM exist in the literature, however, the vast majority of authors consider LCM as sustainability-related actions of a corporation. The researcher is introducing a conceptual framework to guide the study of LCM types based on the gradual analysis of LCM literature. The LCM elements that are identified here will form the base for the analysis of LCM case studies later in this chapter.

2.2.1.1. Data

The definitions, descriptions, and concepts that have been identified in the literature are described in this section. The researcher identified thirty descriptions, twenty-five definitions, and ten concepts. Except for concept papers, the overlapping of definitions and descriptions were limited. Many papers have either a description or definition, but even more papers did not provide any.

LCM definitions

Table 2 provides short statements that define the focus of LCM (Appendix 1 gives the full list of LCM definitions). It is important to mention that if the definitions identified will be related to the three types of LCM owners as stated by (Balkau and Sonnemann, 2010), there is a blend of attention to the individual company and the multi-stakeholder collaboration while governmental policies are not mentioned at all. Also, the characterisations of LCM (in blue characters) vary without being able to distinguish any.

Table 2. LCM definitions identified in the literature.

Authors	LCM definition
Linnanen et al. (1995)	*'the integration of environmental issues **into the company's** decision-making processes, consideration of the environmental effect over the product **lifecycle** necessitated by the **product stewardship** and the importance of cultural change in environmental management processes.'*
Fava (1997)	*'the linkage between **lifecycle** environmental criteria and an **organisation's** strategies and plans to achieve business benefits.'*
Finkbeiner et al. (1998)	*'A comprehensive approach—towards product and origination related environmental management tools that follow a **lifecycle perspective**.'*
Saur (2001)	*'a flexible, integrated, framework of concepts, techniques and procedures to address environmental, economic, technological and social aspects of products and **organisations** to achieve continuous environmental improvement from a **lifecycle perspective**.'*
Hunkeler et al. (2004)	*'an integrated framework of concepts and techniques to address environmental, economic, technological and social aspects of products, services and **organisations**.'*
Baumann and Tillman (2004)	*'the managerial practices and **organisational** arrangements that apply **lifecycle thinking**. This means that environmental concerns and work are coordinated in the **whole lifecycle instead of being independent** concerns in each company.'*
Remmen et al. (2007)	*'a product management system aiming to minimise environmental and socioeconomic burdens associated with an organisation's product or product portfolio during its **entire lifecycle and value chain**.'*
UNEP/SETAC (2009)	*'a **business** management approach that can be used by all types of **business** **(and other organisations)** in order to improve their sustainability performance. …, its purpose is to ensure more sustainable **value chain** management.'*
Puglieri et al. (2013)	*'a **business** approach to improve the **companies'** sustainable performance aiming the long-term value creation in the **whole lifecycle**.'*
Gemechu et al. (2015)	*'an approach to help **companies** set up initiatives, to achieve environmental, economic and social benefits at the same time through implementing a step-by-step quality management tool.'*

While reading through the definitions and descriptions, the researcher was able to distinguish four LCM elements: the value chain (VC) standpoint (in bold), the objectives (in yellow highlight), the focus (underscored) and the tools (in purple characters). The VC standpoint focuses on the product's VC or the organisation. The objectives allow to analyse the product's LC issues and integrate information into organisational processes. Likewise, the LCM focus point to the specific direction that LCM actions take and are implemented/attempted through the tools mentioned.

From the identified LCM elements analysis it seems that objectives are the central element of LCM. From the analysis of objectives, it seems that there are three distinct types of objective. The first type of objective is concerned with the awareness or improvement of sustainability aspects which can be obtained as a result of sustainability analaysis. The second type of objective discussed in the literature is concerned with embbedding or integrating these aspects in organisational/value chain processes. It is interesting to observe the

variability of words used to address this in the definitions (i.e. integration/linkages between/related/apply-coordinated/associated with/used by/set up initiatives). The last objective type uses language that points to progression through time (i.e. cultural change, strategies, plans to achieve, towards, continuous improvement, aiming to, long-term, quality management).

LCM descriptions

Table 3 presents seven of LCM descriptions identified in the literature (the complete list can be found in Appendix 2). These are the statements that further explain the meaning and application of LCM concept as each researcher adds his views and experiences.

Table 3. LCM descriptions in the literature.

Authors	LCM description
Weidema (2001)	*'As a management paradigm, it includes the concepts, tools and procedures to reach this objective [continuous integrated optimisation of economic, technological and social aspects of products]. The original inspiration behind LCM comes from Product Lifecycle Assessment (LCA), a technique to assess the environmental impacts related to a product with the aim of minimising these impacts seen over the entire lifecycle of the product, from raw material extraction to final disposal. In LCM, the **lifecycle concept** is expanded to other areas of concern, notably management of economic costs and quality.'*
Klopffer and Heinrich (2002)	*'LCM is a concept rather than a method or a tool (such as Lifecycle Assessment (LCA), Lifecycle Costing (LCC) and others) and, as such, has obtained much attention. The relation between the concept and the tools, however, is not well established and deserves a thorough and critical discussion. … The concept of LCM is broader than LCA or LCC, aims at sustainable industrial development (in this context the 'triple bottom line' has been mentioned frequently) and uses a 'tool box' rather than one well-defined method. At a closer look, however, it seems that each group uses its own approach and mixture of methods and it is not always clear how well the methods taken out of the tool box are tuned in or fit together. The most serious problem is that different lifecycle tools have to use the same system boundaries in order to provide compatible results.'*
Heiskanen (2002)	*'LCA-based ideas and tools can be viewed as emerging institutional logics of their own. While LCA makes use of many scientific models and principles, it is more a form of accounting than an empirical, observational science. Thus, the lifecycle approach implies a kind of "social planner's view' on environmental issues, rather than the minimization of a company's direct environmental liabilities.'*
Rebitzer and Buxmann (2005)	*'LCM is based on a perspective that focuses on products and the corresponding processes in addition to facilities and production sites. Therefore, the lifecycle assessment (LCA) methodology plays a central role in implementing LCM. … LCM can be seen as a framework for the implementation of sustainable development on the **business level.** … It is a concept, which may be useful in moving towards sustainable development and a means of linking environmental improvement with economic efficiency. … LCM is applied on a voluntary basis and can be adapted to the specific needs and characteristics of **individual organisations**. … LCM facilitates transparent internal and external communication. … LCM's toolbox makes use of existing environmental tools and management systems, which may include national or international voluntary standards and validated indicators or metrics. … LCM supports the business assimilation of integrated product policy, eco-labelling, design for environment, green procurement, and other product or market related business or government initiatives.'*
Balkau and Sonnemann (2010)	*'LCM constitutes an approach that clamps partnerships and procedures to minimize impacts in a **holistic fashion**. LCM helps **product chain actors** to work **both on local and system level** improvement because it can more easily address **global issues and system dynamics than instruments designed for individual use**. … an umbrella framework for combining and applying other management instruments in a more **holistic life chain perspective**.'*
Mazijn and Reveret (2015)	*'Lifecycle sustainability assessment (LCSA) contributes to the assessment and lifecycle management (LCM) to the follow-up of exercising due diligence, all within the context of sustainable development.'*
Gemechu et al. (2015)	*'LCM has been identified as the way to operationalize sustainability challenges into **business** practices; however, its implementation faces significant challenges. Setting clear and measureable goals is one of the challenges. The focus of LCM initiatives is different from the usual business strategies, which are mainly focusing on maximizing the profit as the ultimate goal. LCM initiatives have a wider scope in order to have both social and environmental benefits along with maintaining the economic advantages. The divergent priorities between the financial and sustainability focuses are challenging tasks for managers at different organisational level. A successful implementation of LCM then needs full integration across the **organisation**.'*

Compared to Table 2, Table 3 descriptions add two other elements; the focus and LCM tools. As descriptions are often more detailed than definitions, the researchers provide more details on the LCT focus and the intra- and inter-organisational processes of information integration. Regarding LCM tools, it seems that LCA is the dominant tool. The LCM characteristics pool is enhanced, while some descriptions emphasise what LCM is not than what it is. Also, the descriptions references in the elements add up to the observation that objectives are the core/central part. For example, Heiskanen (2002) that was mentioned in Sonnemann et al. (2015) definitions list is stated here as a description because it does have any objectives.

LCM concepts

The analysis of the LCM definitions and descriptions highlighted four LCM elements (e.g. VC standpoint, objectives, focus and tools). In this section, the limited literature focused on conceptual approaches to LCM will be analysed using the four LCM elements lenses. A description of the readings to be analysed can be found in appendix 3. These readings were selected because they offered a conceptual approach on LCM. The researcher divided all concepts into main and supportive as described in Table 4. The main concepts address all elements of the analysis, while supportive concepts address only some of them.

Reading Table 4 vertically we can see the fit of the four LCM elements to each concept identified in the literature. Whilst reading horizontally we can see the fit of each of the elements across the concepts. It is very interesting that the four LC elements approach varies from concept to concept.

Table 4. LCM concepts analysis.

4 LCM elements		Main				Supportive					
		Linnanen et al. (1995)	Westkamper et al. (2001)	UNEP/SETAC		Labuschagne and Brent (2005)	Remmen and Thrane (2007)	Finkbeiner (2011)	Swarr et al. (2011) and Swarr et al. (2015)	Thabrew et al. (2009)	Scandelius and Cohen (2011)
				Saur et al. (2003)	Jensen and Remmen (2006)						
VC standpoint	Holistic	Balanced	Only holistic	More on holistic		Only holistic	More Actor of VC	Holistic	Both	Only holistic	Only Actor of VC
	Actor of VC										
Objectives	Sustainability assessment (SA)	More attention on IM	Most of the attention on IM through PDM	Only SA and IM – mostly SA	All three	Only SA and IM	Only IM and CI; SA is addressed as part of LCA	Only SA; SA is addressed as part of LCM.	Only IM, CI. Mostly on CI	Only SA	Only IM
	Integration management (IM)										
	Continuous improvement (CI)										
Focus	Product/ Process/Place	Product only	Product and Process	All three		All three	Product and Process	Vague	Vague	Vague	
	TBL	Ecoefficiency (Environmental ->Economic)	Environmental only	More environmental		Environmental	More environmental				
	Intra-/Inter-organisational	Both	Only inter-organisational	Both	They introduced the terms	Vague	Vague			Vague	Both
Tools (the underscored ones are not mentioned elsewhere)		LCA, EMS, Eco-design, QM, Change management framework	LTE/LCA, LTM, PCM, QM	Toolset	Same as Saur et al. (2003), PDCA	LCA, KPIs	Toolset	LCSA	Capabilities models	Vague	

The VC standpoint varies from solely holistic to the main actor in the VC. The three LCM objectives varies across concepts. An interesting finding is that intra-organisational collaboration fits well with cases that adopt the Actor of the VC standpoint, whilst inter-organisational collaboration fits across all VC standpoint approaches. Taking a closer look of the way inter-organisational collaboration is described it was identified that UNEP/SETAC points to VC level collaboration, while Remmen and Thrane (2007) and Scandelius and Cohen (2011) point to the collaboration aspect of the actor in cases where there are other VC actors. Other concepts, such as those from Linnanen et al. (1995) do not make it clear if inter-organisational collaboration is taken from the VC or from an actor's perspective. On the final two focus factors it seems that there is a link between the TBL/3Ps and the tools used. On the tools as described in Table 4 most of the concepts add a new tool [e.g. Linnanen et al. (1995) add a change management tool, Westkamper et al. (2001) add PLM] whilst LCA is the only tool addressed by every concept.

2.2.1.2. Analysis

Through the analysis of the LCM definitions, descriptions and concepts in section 2.2.1.1., the researcher identified four elements that help to structure the theoretical part of the LCM literature. These four elements and their options are described in Figure 6. The LCM elements are very important for analysing the LCM literature and identify any conceptual gaps.

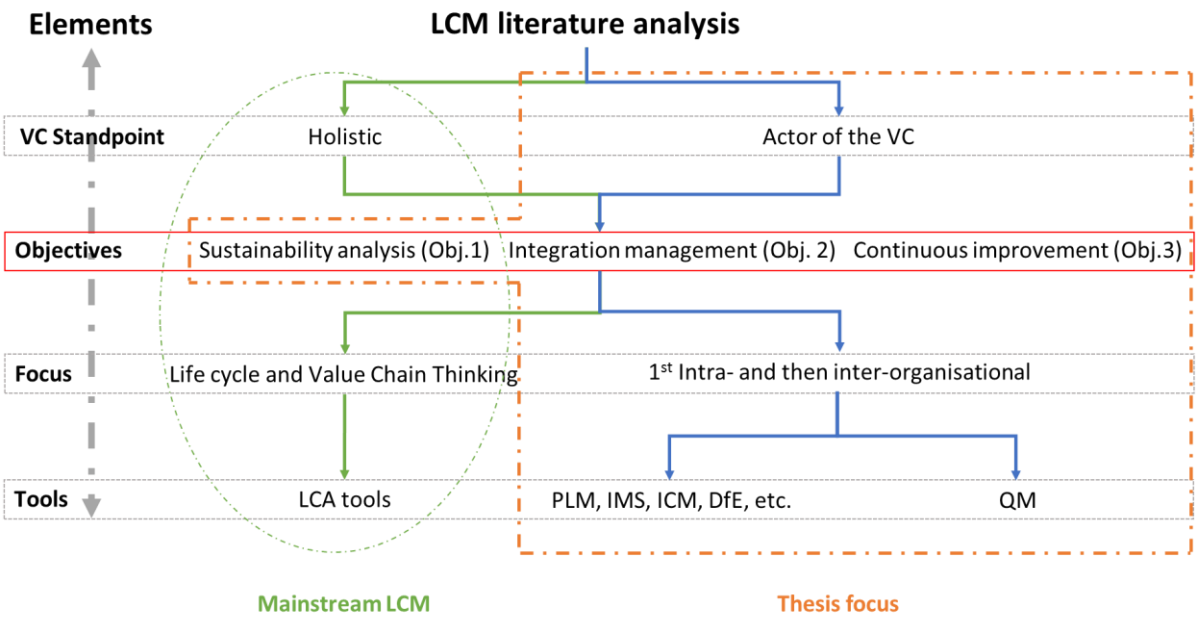


Figure 6. LCM elements flow.

Value chain (VC) standpoint

The first element is the value chain (VC) standpoint, it is mostly mentioned in the definition and description Tables. Two aspects of this element were identified, including the holistic view of the value chain and the perspective of the value chain actor that has to collaborate with the other value chain actors to improve sustainability performance.

The majority of the LCM definitions adopt both approaches. The researcher believes that both standpoints are sides of the same coin, as a company needs to have the holistic view of the value chain to identify risks and opportunities. Moreover, at the same time have a role in the value chain and have to make decisions at their company level and that could also affect other value chain actors or be directed by other actors. Mazijn and Revéret (2015) look at this dual aspect by linking it with the definition of 'due diligence' of ISO 26000 (ISO, 2010) on sustainability. Even the researchers that have a PLM approach [i.e. Westkamper et al. (2001), Ameri and Dutta (2005) and Grieve (2006)] who are focused on the holistic approach, mention the use of the information for the individual companies of the value chain. A good example of the difference between holistic and VC actor standpoint are Figure 67 on the holistic standpoint and Figure 68 on the VC actor standpoint.

The literature resources that in the described approach to LCM adopted the holistic view only included the OECD (1994) report that consider an eco-labelling scheme, and Zbicinski et al.

(2006) who focused on LCA of products. Their perception could be explained by the focus of the authors on the product with no consideration of the firm's approach.

Objectives

The objectives of LCM in the definitions vary, but the common denominator is the integration of sustainability-related information in organisational or value chain processes. That is why sustainability-related PLM definitions have similarities and overlaps with LCM definitions, and they appeared in the LCM literature search.

The stated objectives vary: some authors mention the integration management of sustainability aspects in decision-making or organisational strategies, integrated supply chain management, etc., but these aims could be categorised under the integration management, sustainability analysis, and continuous improvement (CI) perspectives.

The researcher believes this approach brings clarity to LCM as it describes its 'raw materials', as most of the attempts to define/describe/conceptualise LCM are based on a combination of the LCM objectives. For example, Westkamper et al. (2001) suggest in his concept that LCM consists of four fields, but all of them can be analysed using the three objectives. Life Time Evaluation (LTE) follows the sustainability analysis objective through the lifecycle assessments to identify design hotspots. Design for Lifecycle integrates the LTE information into product design (integration management objective). Similarly with Product Cycle Management, life cycle model information is used to support the end-of-life design options. Life Time Management appears to fit to the continuous improvement objective as it transfers knowledge across VC stages to improve the users experience and provide opportunities for improvement to the designers.

On the sustainability analysis (objective 1), the approaches aim for the analysis of a situation and provide information on risks and opportunities. Thabrew et al. (2009) and Finkbeiner (2011) concepts are clearly focused on the analysis objective.

Regarding integration management (objective 2), all the approaches described aim to provide information to decision makers on sustainability aspects and establish their integration in organisational processes. Saur et al. (2003), Remmen and Thrane (2007), Remmen et al. (2007) and Scandelius and Cohen (2011) fall into this category.

Continuous improvement (objective 3) is only mentioned by Linnanen et al. (1995), Jensen and Remmen (2006), and Swarr et al. (2011 and 2015). These authors discuss the importance of developing a culture and capabilities development for the organisation to integrate the sustainability analysis information in organisational processes. In addition, Norris (2001), Remmen and Thrane (2007) and Jørgensen (2008) support the use of QMS/TQM in LCM.

Focus

The focus of the LCM research follows variable directions, the LCM concepts that support the sustainability analysis objective typically have a lifecycle thinking focus, with the integration management and CI objectives focus on intra- and inter-organisational collaboration.

When the authors focus on lifecycle thinking, all the definitions address the product lifecycle, but some researchers' concepts include additional dimensions such as production process and assets lifecycle (Labuschagne and Brent, 2005; Remmen and Thrane, 2007), and the importance of location in relation to the processes across the value chain (Jensen and Remmen, 2006; Thabrew et al., 2009).

About intra- and inter-organisational focus, each definition aims to enhance sustainability performance at different points of the value chain. Some researchers (Linnanen et al, 1995; Remmen and Thrane, 2007) look exclusively inside the organisation's boundaries (intra-organisational), while others (Westkamper et al., 2001; Scandelius and Cohen, 2011) focus on the value chain (inter-organisational), and the rest (Saur et al, 2003; Remmen et al, 2007) consider both intra- and inter-organisational focus. The vast majority of listed definitions point to both intra- and inter-organisational performance enhancement.

The primary integration focus is on intra-organisational collaboration as the majority of the concepts point to decisions that have to be made at the level of intra-organisational actors (i.e. improvements in product design, processes across the value chain, etc.) and later to be communicated to the value chain (inter-organisational). The inter-organisational aspect can have two standpoints as there are decisions that the organisation has to externalise and/or to internalise.

Tools

As far as tools and management systems are concerned, lifecycle tools are the base of the analysis perspective of LCM. However, there is a long list of design tools and management systems, that fit under the umbrella of the integration management perspective of LCM, however, the literature [such as Poikkimaki (2006) and Sonnemann et al. (2015)] does not provide a definite answer on how the management system for the integration of sustainability aspects in organisational processes works. Only, Saur et al. (2003) brings a list of tools together (Figure 61), while the majority of the authors mention a selection of these tools. The literature analysis concludes that LCM is a toolbox rather than a well-defined concept.

LCM elements contribution

Many LCM researchers such as Klopffer and Heinrich (2002), Poikkimaki (2006), Jensen and Thrane (2007) and Sonnemann et al. (2015) characterised LCM as a vague concept; therefore, the researcher has attempted to bring structure to the LCM literature analysis by using the elements of LCM approach. The researcher proposes a four elements approach (Figure 6), where each element answers a question about LCM.

- The value chain element emphasises the analytical approach to the value chain with some researchers emphasing a hollistic approach and others an actor approach - how.
- The objectives element highlights the reasons behind LCM approach - why.
- The focusing element stresses on what and where is the concentration of LCM.
- The tools element underlines how LCM takes place.

With the application of this four-element filter to the literature the researcher was able to define three successive objectives of LCM, where each objective has its own flow across the elements.

Sustainability analysis is the first objective; it has a holistic VC standpoint that is assessed having an LCT focus using LCA tools to identify risks and opportunities.

Integration management is the second objective; it has a VC actor standpoint as the information of the sustainability analysis objective need to be internalised in the organisational processes. The internalisation takes place first by intra-organisational dissemination of the information to inform decisions, which might require inter-

organisational actions. There are variable tools on taking action at specific parts of the organisation, but the concept of managing the integration is missing.

Continuous improvement is the third objective. Continuous improvement implies enhancement of the integration management implementation after each implementation cycle. Except for Saur et al. (2003) that used the PDCA approach at project level and some other researchers highlighting quality management and capabilities development as useful tools, there is no structured approach on continuous improvement.

2.2.2. LCM corporate case studies

The LCM cases identified in the literature will be described and analysed using the four elements approach.

As LCM definitions, descriptions and concepts are grounded in practice, the analysis of LCM implementation will provide an understanding of LCM. At the moment, there are limited LCM implementation cases available. The following comment determines the need for more information on LCM implementation by organisations.

'*The review of the LCM literature indicates that it provides many normative prescriptions of what LCM is, including what tools, methods, and approaches to use. But they also tell us that in fact this literature indicates in fact what ought to be considered, but without providing compelling descriptions and analysis of the difficulties involved in organising LCM in practice. This is a common critique about the state of development of LCM* (*Mazijn and Revéret, 2015).'*

LCM is suggested by UNEP/SETAC as a very promising approach, this does not suggest that non-LCM approaches/concepts cannot be better. However, the attention of this research is on LCM.

2.2.2.1. Data

In this section, LCM cases discovered in the literature are described sequentially. Presented cases include all substantial cases in academic literature while corporate reports and other 'grey' literature were not used. This section includes thirty cases using the four elements concept presented in the previous section. Due to the word limit of this thesis the thirty LCM cases description are moved to Appendix 4.

2.2.2.2. Analysis

Appendix 4 provides a description of thirty business cases where forms of LCM were applied. The author analysed these cases using LCM elements as lenses based on the LCM theoretical literature analysis earlier. The researcher marked the appearance of each element in a distinct way as described in Figure 6 while providing the appearance of quantitative analysis in Table 5. In addition, Appendix 5 provides the analysis of a case study. Table 5 provides quantitative analysis of LCM elements (Objectives and Focus). It should be noted that most of the cases did not describe all LCM actions related to the case company, but addressed them only partially. Therefore, the results presented in Table 5 reflect the analysis of published cases and not the analysis of LCM adoption by the listed case companies.

Table 5. Case studies elements quantitative analysis.

Elements			**Results (32 cases)**	
Objectives	Sustainability analysis		32	
	Integration management	Project	32	10
		Process		22
	Continuous improvement		12	
Focus (LCT)	Product		26	
	Production process		22	
	Asset		4	
	Place		3	
	Stakeholders		1	
Focus (intra-inter)	Intra-organisational		31	
	Intra -> inter		11	
	Inter -> intra		5	
	Inter		1	

The use of LCM elements has been linked to the three objectives, two of them (i.e. sustainability analysis and integration management) has appeared in all cases, and a form of CI has appeared in one-third of the cases. However, the use of continuous improvement has been stated without providing any specific details.

The sustainability analysis objective used in all cases is related to the identification of risks and opportunities. The lifecycle focus varies, but in all cases with a physical product the main focus of the analysis was on product lifecycle. Two-thirds of the cases included production processes analysis and a limited number of cases considered assets and the interaction with the local environment. In only one case the company considered the stakeholders.

The use of integration management objective was used in all cases to provide information to decision makers. In one-third of the cases (including all five SMEs in the sample) LCM actions

were related to a project, while in the majority of cases, LCA was part of their organisational processes. The projects were linked only with intra-organisational collaboration, whereas many of the companies with organisational processes had inter-organisational cooperation as well. In every third case, companies stated inter-organisational cases where the decision flow was from the case corporation to value chain actors and one-sixth of the sample had flow from a value chain actor or a stakeholder to them. Only the Poikkimaki (2006) case had solely inter-organisational focus adopting a holistic view of the value chain.

Regarding the tools and management systems linked to the integration management objective, except LCA it is not clear how companies operate. LCA is the dominant tool that is used in all cases, and in some cases the companies have created their simplified LCA tools that fit better to their needs. On intra-organisational management tools only EMS, H&S and eco-design tools were mentioned. On the inter-organisational part tools like Integrate Chain Management (ICM), Integrate Product Policy (IPP) and Product Oriented Management Systems (POEMS) were mentioned.

The CI objective was also mentioned in some cases pointing to make LCM part of routines, establish patterns of collaboration and exchange of information among organisational functions and with value chain actors.

Compared to theoretical definitions, descriptions and concept, the appearance of the four elements in cases are different. On the value chain standpoint, it seems that there are aspects of both as the approach usually is to integrate the holistic approach into the actor(s) decision making.

Regarding objectives, there is an over-representation of sustainability analysis. Nevertheless, the aim is to use this information to support integration and management and/or continuous improvement.

On LCM focus and tools used, the is focus usually on a project or a product and the related use of tools is attached to the specific focus. This shows a limited use of the LCM-toolbox in practice.

Throughout the case analyses the researcher realised that in action (i.e. the cases) the appearance of the four elements was usually linked to certain factors/conditions relating to

managerial actions or decisions. The text that refer to this point was marked in order to be further researched.

2.2.2.3. Factors analysis

The text in literature cases analysis that was marked for further research (as mentioned at the end of previous sub-section) was cut and pasted into a new document. Then parts of the text were tagged with the characteristic that they advocate. Those tags that refer to a common theme were grouped which led to the eight factors identified.

The identified factors are described below along with typical quotes from the analysis of the LCM literature cases. An example of LCM case analysis is described in appendices 5 to 7.

1. Highlighting. This triggers the interest to analyse/integrate sustainability aspects usually beginning with action by regulators (a), value chain collaborators (b) and analysts (c).
   a. *'Products, processes, and the plant are heavily regulated.'*
   b. *'The company has some major clients, especially for powdered coatings, that place high importance on the environmental profile of their suppliers.'*
   c. *'The case study revealed that the environmental improvement strategies of an SME in the field of paint production—based on an EMS/production view— were inefficient.'*
2. Collaborating. This focuses on establishing intra/inter-organizational collaboration for sustainability analysis or processes.

   Inter-organisational collaboration for sustainability analysis: *'The company joined a multi-client project, which was led by a university as the LCA consultant.'*

   Intra-organisational collaboration for establishing processes*: '[Our] eco-design initiative requires a transversal approach involving diverse teams. Life cycle management ensuring collaboration between different departments within the company and with stakeholders outside the organization is key to implement and sustain such an initiative.'*

3. Analysing. This supports sustainability analysis on the identification of hotspots or support of strategy and decision making.

a. *'Given the evidence for this and other similar studies, …'*

b. 'Prior to the choice to develop a specific tool for product ecodesign, a detailed requirement analysis was completed indicating that the ideal tool has to: …'

c. *'The use of LCA confirmed that …'*

4 Strategising. This endorses certain highlights or analysis results through public reinforcement.

'The company recognised the potential to differentiate itself by offering environmentally preferable products.'

'The purchase and choice of raw materials was defined as a new focus to improve the environmental performance.'

'The company identified worker safety and environment as key management guidelines.'

5 Decision making. This refers to the decisions that have been supported by sustainability analysis.

'LCA can assist in DfE, assist supplier audits and choice of materials, and assist in investment decisions.'

'Give reliable results: although the tool is a simplified tool, the results must be as robust as possible to support relevant decisions.'

6. Implementing. This refers to putting strategy/decision making into action.

'… optimisation strategies were defined and implemented into the EMS.'

'In cases where LCA studies were performed by an external consultant, the conclusions could not be implemented in the design process.' This is a multi-factors example, inter-Organisational collaboration on analysis has impact on the integration of the information in an intra-organisational process.

7. Sustaining. This focuses on implementing and expanding the processes.

'The packaging designers using life cycle assessment to support their design choices is significantly increased.'

'The number of tool users has increased to reach 700 people today.'

'… and obtained certification according to the European eco-management and audit scheme (EMAS).'

8. Knowledge development. This pays attention to training (a), expanding of interest (b) and learning through time (c).

    a. *'There have been many challenges to overcome, such as: the availability and the management of inventory data, following-up the latest methodology, as well as the training and education of users.'*
    b. *'Product designers may work on an alternative design that improves the environmental performance of the product. In the past, in the absence of EcodEX, designers were not always aware that their designs had negative impacts on the environment.'*

       '[Company name] has launched several R&D projects to further investigate new sources of protein with improved environmental performance.'
    c. *'After the successful the 'low-hanging fruits' based on corporate ecobalances, he was looking for new approaches and tools to continually improve the environmental performance.'*

       'The main conclusion of the company was that its strategies, targets, and programs to improve the environmental performance of its organisation had to be redefined.'

2.2.3. Sustainability analysis over-representation in LCM literature

The study of LCM literature gives an impression of over-representation on the sustainability analysis objective compared to integration management and CI. The researcher further explored presence of sustainability analysis objective in the proceedings of two international LCM conferences.

Finkbeiner (2011) as an editor of the book that is based on the 5th International LCM conference presentations provides a list of eight papers that are focused on LCM methods and tools. All eight papers are focused on LCA rather than LCM.

- Wang et al. (2011) presented a new LCIA weighting method,

- Baumann et al. (2011) discussed the consideration of value chain actors influence in LCA,
- Langlois et al. (2011) focused on the land use consideration in LCA,
- Moeller and Prox (2011) brought up the need to design software that will help initiate discussions around sustainability issues,
- Chomkhamsri et al. (2011) provided a critical review of the ILCD Handbook on LCA introduced by the European Commission,
- Collet et al. (2011) described a method that allows to introduce time in the inventory stage of an LCA and converted it from static to a dynamic model,
- Steinfeldt (2011) described a method to conduct better LCAs on nano-technological techniques,
- and Rønning and Lyng (2011) reviewed the LCA literature and provided a study on how the performance of buildings and construction is measured.

Then the focus of the presentations moved from LCA to water footprint related papers and then back to sectoral LCA studies such as food, packaging, energy, electronics and mobility presenting LCAs and the risks and opportunities identified without providing information on how this information affected the organisational processes.

When having a look at the Proceedings of the 6th International Conference on LCM the main focus was still on LCA rather than implementation of LCM. Most of the presentations were focused around LCA, such as the influence of communicating LCA information to stakeholders, the influence of LCA on environmental policy, and many sectoral presentations of LCAs and the risks and opportunities identified for the sector. Several papers analysed managerial practices in LCM,

- Nilsson et al. (2013) discussed the influence of LCM in organising more sustainable value chains,
- Schmidt (2013) initiated the discussion on the social/organisational practices that are influenced by LCM,
- and Clancy et al. (2013) mentioned the concept of actionable knowledge (identifying strengths and improvement areas) in the development of more sustainable products.

The study of the two conferences confirms that the available LCM research is more focused on sustainability analysis objective. In corporate sustainability, LCM as a term came from the

need to utilise the product LCA information in decision-making. Most of the researchers who have published on LCM have a strong background on LCA (sustainability analysis), and LCA is their main research topic. As a term, LCM sounds appropriate for the sustainability analysis objective of LCM, but the various activities seem to gather under LCM could term it as a method to establish sustainability integration in organisational processes. LCA is a main aspect of LCM, but it is not the LCM concept.

2.3. Conclusions

There are variable definitions, concepts and business cases on LCM, but the way authors approach LCM is often abstract and unclear. For the researcher LCM is a management concept to organising the integration of sustainability across the organisation. Based on the analysis of LCM literature the author proposes the following definition:

LCM is a management concept that aims for the integration of sustainability-related information to organisational processes to enhance the sustainability performance of the organisation and its value chain.

It also seems from the LCM literature that the LCM approaches target the means/tools of LCM, whereas they should focus on the messages/information that LCM should pass.

Therefore, the researcher introduced three LCM objectives that could be used as a base in creating a more detailed concept on corporate LCM. The analysis provided by the researcher and summarised in Table 4 demonstrated that the sustainability analysis objective received most of the attention in the literature on LCA and LCSA. Some authors mention the integration management objective, however, the literature is lacking detailed concepts and frameworks on how it operates. Except for Linnanen et al. (1995) and Swarr et al. (2011 and 2015) contributions, there is no information on the CI objective. Only, Jensen and Remmen (2006) mention it in the LCM Deming cycle implementation (Table 51), and Remmen and Thrane (2007) introduce the knowledge management perspective by mentioning the link between LCM and quality management processes.

Researcher's views are very close to Linnanen's et al. (1995), they touched upon the three most important tasks of LCM, that according to the researcher are:

- applying tools to analyse a situation (sustainability analysis objective),

- developing the processes that will integrate the analysis of information in decision-making (integration management objective), and
- working on the culture of the organisation to make the analysis and integration views a developing part of their routines (CI objective).

The researcher believes LCM is not the integration of tools or an analysis process, but an integration concept that assimilates the information provided by analysis into organisational processes.

Companies usually develop a strategy on sustainability and deliver actions at the operations level (Labuschagne and Brent, 2005). However, the organisational processes level, where the decisions are made, is vaguely described. Nilsson-Linden et al. (2014) linked the ambiguity to the middle management dilemma; middle-level managers have lots of things to consider, sustainability is one of them, however it is not prioritised. As a result, LCM processes are not developed in many cases.

Relation between the LCM conceptual framework and organisational levels is another important aspect for this research that is not highlighted by the concepts in the literature. Labuschagne and Brent (2005) addressed the organisational processes level methodological gap as described in the Introduction, and Finkbeiner (2011) mentioned that LCM provides solutions to enhance the decision-making into strategy and operations levels. It seems that Finkbeiner (2011) is not focusing on the organisational organisational processes level because since he is looking through the sustainability analysis objective only (holistic than VC actor standpoint).

There is a need to put more emphasis on the integration management objective compared to the sustainability analysis. The literature review gives the impression that case studies provide more information about LCM than the definitions and concepts. It seems there is a need to study how companies work on the organisational processes level, as there is no comprehensive understanding of what LCM exactly is. Also, based on the integration management objective descriptions in the literature, LCM is described as a static process, focusing on the current state and processes, while its dynamic nature (i.e. development through time) lacks despite the accumulation of more knowledge on sustainability within the organisation.

From the study of the theoretical and applied part of the LCM literature, it is obvious that in practice all three LCM objectives are being applied, however, there is an absence of detailed concepts on the integration management and CI objectives. The LCM so far seems to give solutions to projects and does not develop the structural changes for integration management. It also became apparent that there are no detailed examples of LCM application in the literature. Another very important aspect for LCM is the absence on integration management and continuous improvement related tools. The discovery of these gaps helped the researcher to focus this research more on the exploration of integration management and continuous improvement objectives.

3. Research method

This chapter highlights the research methods and design utilised in this study by systematically discussing the data collection activities and associated methods of analysis.

3.1. Research methodology flow

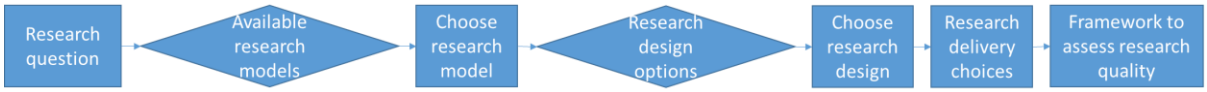


Figure 7. Research methodology flow.

As a part of the research process, the researcher explored the research methodology literature and based on the obtained knowledge made some decisions on the research methodology. The research method decisions made are:

- Posing a research question that would enhance the knowledge and application of the research topic.
- Explore the available research models and choose the one that better fits with the research question.
- Based on the chosen research model explore the related research designs and choose the design that better fits the research question.
- Develop a research action plan that will be described in detail in the following chapters.
- Introduce a research quality framework that will be used in the discussion chapter to assess this research attempt.

3.2. Research aim

The overall aim of this research is to participate in organisational sustainability projects to:

- explore how these organisations work on sustainability issues (= 'how companies internalise sustainability aspects'),
- explore the methodological gap at the organisational processes level as was stated in the Introduction,
- discover the potential of three LCM objectives stated in Chapter 2 to reduce the organisational levels gap,

- identify the factors influencing sustainability aspects (= 'the 'blend' of the sustainability challenges that each company works on'; sustainability is a multifaceted challenge and each company works on a different facet 'blend') integration in organisational processes and propose improvements.

The above mentioned aims of this research will be explored through the following research question:

What are the factors that influence the integration of sustainability aspects in organisational processes?

A factor focused research question was chosen because the researcher believes that is good choice, as the research topic is not explored in depth. The answer to this question will enrich the LCM field. At the same time, understanding of the factors that influence the integration of sustainability aspects allows sustainability managers to address the methodological gap at the organisational processes level.

The three LCM objectives introduced by the researcher in Chapter 2 is not a hypothesis to be tested, the objectives are coming from the analysis of the literature and are used as a compass in the exploration of the integration factors.

3.3. Research model

This section discusses the available research paradigms characteristics, and then based on the chosen paradigm the method that better fits to the research question. The researcher believes that critical realism is the research paradigm and action research is the method that best addresses the proposed research question.

There are certain principles and directions provided by research methodology to frame the actions and beliefs of a scientist to inform others on their research approach. The sets of principles and directions are called research paradigms. According to Guba and Lincoln (1994) paradigms are defined as: *'basic belief systems based on ontological, epistemological and methodological assumptions'*.

Alvesson and Skoldberg (2009) and Coghlan and Brannick (2010) state the existence of three traditions in the philosophical foundation of scientific research that are linked with five research paradigms (Table 6). The various combinations of ontological and epistemological

approaches indicate different types of reflexivity (Coghlan and Brannick, 2010). In research, axiology refers to what the researcher believes is valuable and ethical. Basic beliefs about what is ethical guide the researcher's decision-making. The purpose of the inquiry needs to be balanced with what the researcher values as well as other ethical considerations in the conduct of research (Guba and Lincoln, 2005). Researchers often feel that one paradigm fits better than others, however, the research approach fit always depends on the question to be answered.

Table 6. Reference points in the philosophy of science and related research paradigms (Guba and Lincoln, 1994; Johnson and Duberley, 2003; Guba and Lincoln, 2005; Alvesson and Skoldberg, 2009; Coghlan and Brannick, 2010).

	Related research paradigms		
	Positivism, Post positivism	**Interpretivism, Critical theory**	**Critical realism**
Philosophical foundations	Positivism	Social constructionism	Critical realism
Ontology	Objectivist (Realist)	Subjectivist (Relativist)	Objectivist (Realist)
Epistemology	Objectivist (Realist)	Subjectivist (Relativist)	Subjectivist (Relativist)
Theory	Generalizable	Particular	Particular
Reflexivity	Methodological; to support objectivity	Hyper; to invoke alternative voices	Epistemic; to challenge and analyse meta-theoretical assumptions
Role of researcher	Distanced from data; sceptical and disinterested expert	Close to data; narrative therapist	Close to data; committed process facilitator aware of his own habitus
Axiology	Propositional knowing about the world is an end in itself, is intrinsically valuable.	Propositional, transactional knowing is instrumentally valuable as a means to social emancipation, which as an end in itself, is intrinsically valuable.	Practical knowing about how to flourish with a balance of autonomy, cooperation, and hierarchy in a culture is an end in itself, is intrinsically valuable.

3.3.1. Choosing a research paradigm

The research question to be explored will be seen through the lenses of each research paradigm. The use of the falsification approach exemplifies why critical realism is an appropriate way to explore the research question.

The positivistic paradigm is dominantly a quantitative research approach (Paley, 2008), except for some cases of qualitative positivism like historiography (Alvesson and Skoldberg, 2009). This research paradigm is focused on testing and verifying hypotheses (Guba and Lincoln, 1994). Through surveys, the researcher can explore many cases and test a theory. On the other hand, surveys lack depth, as they cannot offer detailed knowledge on specific cases. Surveys are a good choice if the aim is to explore the existence of certain factors in a large

sample (test and verify hypothesis). In the case of this research, the issue is whether qualitative or quantitative research better fits the research question. For this particular research, a qualitative methodology is appropriate as the research is concerned with creating a theory, not testing it (Bryman and Bell, 2011). There are no previously proposed hypotheses. Hence this paradigm is falsified. If certain factors were already identified in the literature, it could make sense to use the positivist approach and statistically identify them in various companies. However, this topic is not well explored, and clarity will increase through using a paradigm that is more engaged/close to action.

The post positivistic research paradigm is focused on studies to falsify certain hypotheses to get as close as possible to reality (Guba and Lincoln, 1994). It can help understand which the best hypothesis is by disproving alternative explanations. It is not about testing a theory, but proving that hypothesis is better than the rest. The post positivistic approach does not fit with the research question, as there is not any hypothesis to be falsified.

Critical theory is based on a specific type of historicism where people are the subject of action as they are historic agents that participate in the action. The timeline perspective and context influence is very interesting to analyse a specific case. This historical base is not directly related to the identification of factors, but their development through time (Budd, 2008). Critical theory would better fit this research if there was a set of established factors and the aim was to explore their longitudinal development in certain cases. Therefore, critical theory will not be the guiding paradigm for this research.

Interpretation as a research paradigm operates on the philosophy that reality is in each person's mind and is considered as correct. Interpretivists believe that truth is contextual. The researcher has a distant/detached approach of the problem without trying to solve it, just describe it (Guda and Lincoln, 1994; Klein and Myers, 1999).

Interpretivists argue that objective reality not exist. Reality only exists in a subjective way as truth is contextual. Interpretivists look for meaning in the experience of individuals, as reality cannot exist without context. Each person has his reality that is considered correct. It is based on the interaction between researcher and participants through observation, interviews and document reviews. The factorial approach of this study's research question points suggests that the factors are one reality, but it is expected that different people have different views

about each factor. Interpretivism encourages a rich description where all things are real; this is an accurate description of the context for this research, but it does not reflect the aim within the research question of finding specific factors. Therefore, interpretivism is felt to be less appropriate to explore the research question.

For critical realists, reality is liberated from researcher's ideas and explanations of reality (Alvesson and Skoldberg, 2009). Critical realists do not have comprehensive preconceptions of the specific mechanism at work, the related important data, and how these mechanisms can be revealed. While allowing for multiple personal versions of reality, critical realism tries to identify and clarify the generative mechanism in a given situation. This is an iterative research paradigm that moves between conception and application, and the ideas are tested on empirical data (O'Mahoney and Vincent, 2014), as the phenomena must be understood in the real world (Alvesson and Skoldberg, 2009). Critical realism is better suited to research the given question compared to the previous paradigms and is used hereafter.

3.3.1.1 Critical realism

Critical realism is further explored, and its ontological, and epistemological fit for the research question is verified.

Critical realism brings together realist ontology (objectivism) with relativist epistemology (subjectivism) (Bhaskar, 1998; Easterby-Smith et al., 2012). An important characteristic of critical realism is the concept of a 'structured ontology' that distinguishes three levels of reality (Bhaskar, 1978; Clark, 2008; Johnson and Smith, 2010; Easterby-Smith et al., 2012):

- The empirical domain relates to the experiences and viewpoints of a person (feelings).
- The actual domain is focused on events, where actions and events are observed or detected (mechanism observed).
- The real domain relates to mechanisms that cannot be directly observed because the reality is too complex.

Critical realism separates the cause - real domain, the event - actual domain, and data of the event - empirical domain (Johnson and Smith, 2010).

The researcher sees a link between the organisational levels as described in Figure 1 and the levels of the structured ontology in the way this research will be conducted. The strategy level

is parallel to the real domain, as at the strategy level except sustainability there are many different strategies considered that cannot be directly observed and make reality not directly observed. The actual domain links with the method at the organisational processes level, as in both cases a mechanism is tried to be observe on the chosen topic. In this case, is to observe the mechanism of integrating sustainability aspects into organisational processes. The empirical domain links with the operations level, as each individual feeling on the implementation of the integration, will help identify the mechanism and its weaknesses.

Relativist epistemology refers to subjective relationship between knowledge and the researcher (Guba and Lincoln, 1994); von Krogh et al. (1994) introduced specifically for corporations, the concept of corporate epistemology theory, and analysed the three philosophical positions on how organisations and individuals interpret knowledge formation (Venzin et al., 1998). Marr et al. (2003) based on Venzin et al. (1998) analysed the three classes of corporate epistemology:

- Autopoietic highlights the different ways of interpreting knowledge by the individual.
- Connectionist emphasises the intra-organisational groups' ownership of knowledge through their self-organised network communication.
- Cognitivist focuses on the transferability of knowledge through centrally disseminated information.

Cognitive epistemology refers to explicit knowledge in an organisation. Autopoietic epistemology refers to tacit knowledge of individuals. Connectionist epistemology relates to connecting the knowledge of different functions which tacit at the company level and explicit at the group level. For example, there is different knowledge in purchasing and marketing groups, as they have different specialism knowledge and views. However, these two groups under certain circumstances they have to cooperate, having an idea of the other group's knowledge would help improve the interaction and cooperation.

The researcher also sees a connection between the organisational levels and corporate epistemology. Cognitivist epistemology links with the strategy level, as the strategies like the sustainability, usually are centrally disseminated information that aims to create action at the other levels. Connectionist epistemology links with the organisational processes level, as the sustainability group and/or sustainability responsible for each group usually create a network

of communication to organize the delivery of the strategy. And each group has a way of processing the obtained sustainability information. Autopoietic epistemology links with the operational level, as each individual acting on sustainability aspects, has his view of interpreting this sustainability information/knowledge.

The author has observed specific links in the relation between structured ontology and corporate epistemology (Table 7). More specifically, there appears to be strong links between the empirical domain and autopoietic epistemology, the actual domain and the connectionist epistemology, and the real domain and the cognitivist epistemology.

Table 7. Links between structured ontology and corporate epistemology.

Structured ontology	Corporate epistemology
Empirical domain	Autopoietic
Actual domain	Connectionist
Real domain	Cognitivist

In this research all three links are going to be explored to a certain extent, but most of the attention will be paid to the actual domain ontology and connectionist epistemology, as the aim of the research is to observe mechanisms and their factors in order to improve the integration of sustainability aspects in organisational processes from tacit to explicit.

3.3.2. Research design

This section introduces different choices for the research design and proposes a specific plan. The critical realist research designs are briefly described in this section.

The research design is the strategic approach that is used to connect the study components (data collection and analysis) in a way that addresses the research problem reasonably and coherently. The research problem dictates the research design and not the other way around (De Vaus, 2001).

According to Ackroyd and Karlsson (2014), two main research decisions dictate the appropriate research method in critical realist research. The decisions are:

1. Focusing on the mechanism (intensive research) or the context the mechanism operates (extensive research). Intensive research is focused on the discovery of generative mechanisms. Extensive relates to research that focuses on the context that

mechanisms operate. Table 8 analyses different dimensions between intensive and extensive strategies. Intensive and extensive research are distinguished by their tendency to follow the abductive or retroductive discovery logic, both logics are used in critical realism. Abductive research focuses on incidents that fall outside of the available theoretical frames. Retroductive research relates to the identification of the conditions that a context cannot exist within (Danermark et al., 1997).

Table 8. Difference between the two research strategies (Evered and Reis., 1981).

Dimension of Difference	**MODE OF INQUIRY** **Intensive**		**Extensive**
Researcher's relationship to setting	Being there,' immersion	↔	Detachment, neutrality
Validation basis	Experiential	↔	Measurement and logic
Researcher's role	Actor	↔	Onlooker
Source of categories	Interactively emergent	↔	A priori
Aim of inquiry	Situational relevance	↔	Universality and generalisability
Type of knowledge acquired	Particular, idiographic: praxis	↔	Universal, nomothetic: theoria
Nature of data and meaning	Interpreted, contextually embedded	↔	Factual, context free

2. Aiming for describing a phenomenon or improving its condition. Regarding the research design, the critical realist research is distinguished between engagement and detachment studies. The detached studies attempt diagnosis only and engaged studies that aim also to have an impact on the investigated subject.

Table 9. Eight designs relevant to critical realist-informed research and some of their characteristics *(Ackroyd and Karlsson, 2014)*.

		Decision 1: Distinctive research strategies			
		Intensive		**Extensive**	
		What is the mechanism? (context as given)	**How do context and mechanism:**		**What is the context? (Mechanism inferred?)**
			typically interact?	**historically intersect?**	
Decision 2: Research design	**Detached study**	Case study	Comparative case study analysis	Generative institutional analysis	Research surveys and census data
	Engaged study	Action research	Intensive realist evaluation	Barefoot historical research	Extensive realist evaluation
Dominant logic of discovery		Abduction		Abduction/ Retroduction	

As described in Table 9, the two abovementioned decisions contain certain factors that classify the eight research designs that relate to critical realism. According to Ackroyd and Karlsson (2014) the options are:

- Case study: it is the basic strategy for critical realism and focuses on the diagnosis of the mechanism only.
- Comparative case study analysis: case study is not restricted to single cases; the comparative analysis of case studies helps to improve knowledge on mechanisms. It focuses on similar or related cases, compares similarities and differences. This allows us to obtain better knowledge on the mechanisms nature and properties.
- Generative institutional investigations: this design shifts dimension and explores the casual sequences of the mechanism over time. It focused on the generative mechanism and contexts historical connection, and its contribution to the unique outcomes of each case.
- Census data for surveys: large-scale surveys do not provide information on the context of the participants. Census data focuses on collecting information on the groups and locations (context) of the respondents, on top of their individual responses related to the mechanism. This design is focused on large-scale qualitative data sets.
- Action research: it is very similar to the case study option; it is differentiated by the fact that active intervention is a key part of action research. It is usually led by the researchers and supported by the participants. The focus is on the mechanism; context is not regarded.
- Intensive realist evaluation: it considers the complexity of the context and focuses on what works for whom given the circumstances. This design assesses the interplay of mechanism and context.
- Barefoot research: it encourages employees to conduct research on their own and draw their conclusions. The employees conduct the research with little support while they do not have research training. The aim is to bring employees closer, share experiences, and identify improvements.
- Extensive realist evaluation: it draws information from intensive realist evaluation and the mechanism and context interplay is further explored using larger samples.

Statistics are used to explore the correlation among interplay variables and to map the interaction among mechanisms and contexts.

3.3.2.1. Choosing research design

An attempt to explore the applicability of the critical realism informed research designs and explain why action research is an appropriate choice for the research question is made.

Focusing on the breakdown of the critical realist research designs available on Table 9 and the research question to be explored, the main research design that will help answer the question will be identified.

The integration of sustainability aspects in organisational processes has not been systematically explored. Therefore, the existing research does not provide a substantial amount of knowledge to provide a foundation for this research. The available information is limited, and the factors of the mechanism need to be identified to advance knowledge. This study will focus on the identification of factors of the mechanism (intensive research) than the context (extensive research). The reason for this is that the research question gives more emphasis on the mechanism than the context. Based on the research question, the intensive approach better suits this research as the principal aim of the research question is to identify the factors (mechanism) of sustainability aspects integration, not the context, also explaining why abduction is the dominant logic.

Regarding the extensive realist designs, the large samples of census data and extensive realist evaluation will not be useful at this stage as the mechanism is not explored. The depth of the information would allow to identify the factors but not to understand them.

Similarly, with generative institutional analysis, there is a need for a mechanism to explore its factors development through time. Hence, this design would be more useful if the mechanism was explored, therefore, it would be useful to explore its development through time.

Barefoot research does not fit with the research question as it is focused on the improvement of a situation and not on the identification of a mechanism. Usually, this design is used when there is enough knowledge about the mechanism, and this knowledge is utilised to find ways to have a better fit with the specific context.

Regarding the research procedure, the critical realist paradigm distinguishes between engagement and detachment studies. The detached studies attempt diagnosis only and engaged studies also aim to have an impact on the investigated subject. Organisational processes are a complex area and to address the question in a better way, it is important to be as close as possible to the study participants. This will provide better access to data and processes. That is why engagement studies is the chosen research design for this study as it aims at impacting the investigated subjects, as a better understanding of the object is obtained this way.

Case study is also an effective option for this study, but when action research is available, then the better access to the phenomenon investigated is of great value. Critical realism points to knowledge that challenge existing power structures and uncovers former misguided beliefs (Kilduff et al., 2011), the purpose of action research is to put this into effect (Ram et al., 2014).

For comparative case study analysis, if the context allows it, action research cases could be compared to certain aspects. This is something that could be utilised. Nevertheless, intensive realist evaluation goes in more detail and explores what works for whom given the circumstances. Intensive realist evaluation design can fit in this research if the comparison between different cases will be attempted.

Whereas action research (AR) is agreed to be the chosen research design, below are some information on AR's difference compared to other research designs.

According to Blumberg et al. (2011), there are four characteristics of action research that differentiate it from other research designs.

1. Action research focuses on real life problems and is restricted by the context, whereas other research methods focus on both real life and scientific problems aiming to identify general principles.
2. With action research there is a continuous reflective research and action process; with the other research methods, there is a clear separation between research and implementation process.

3. The validity of action research is measured on whether the actions solve the problem. With other research methods, the research is established using statistics at core figures and successful replications.
4. In action research, there is not a clear roles division, while in other research methods there is.

Like every method, there are some positives and negatives on action research. Eden and Huxham (1996) mentioned that action research lacks repeatability and it is more consulting than research, but the richness of insight cannot be gained in other ways. Gummesson (2000) points that action research concentrates too much on organisation action, on the other hand, this grounds the theory in action.

Action research has a good fit because close and continuous collaboration with companies, and involvement in some of their sustainability-related projects is essential in exploring the research question. The other research methods are more distant from the company and are less likely to provide the same access and hence the insight quality that action research does.

Table 10 combines key elements of action research offered by Lingard et al. (2008), and their application to this research.

Table 10. Relation of this research with action research elements.

Key elements of Action research (Lingard et al., 2008)	Relation to this research
The research questions arise from a situated problem that is best understood through a collaborative research partnership.	The absence of a methodological framework that connects the three levels of organisational sustainability (Figure 1).
The research agenda and activities shared by researchers and partners.	The research cannot be developed without conducting studies with companies and learning from each other, as there is limited information in the literature.
The results meet the partners' needs in a collaborative and equitable manner.	The research helped partners to become more efficient in integrating sustainability aspects in the organisation. This is the main reason why partners collaborated with the researcher.

3.3.2.1.1. Conducting action research

The main choices when implementing action research as identified by the researcher, and different literatures that this researcher has used to inform the detail design of the research are described.

The main characteristic of action research includes researcher's involvement, active work at making something happen, instead of observing what happens (Dickens and Watkins, 1999; Gummesson, 2000; Koshy, 2010). Action research has dual objectives: to solve real problems within an organisation and to contribute to science (Argyris et al., 1985; Gummesson, 2000; Koshy, 2010; Bryman and Bell, 2011; Easterby-Smith et al., 2012; Ram et al., 2014). Action research bridges the gap between research and practitioners (Bryman and Bell, 2011) and it is fundamentally about change and changing patterns of thinking and action (Argyris et al., 1985; Gummesson, 2000; Waterman et al., 2001; Huxham and Vangen, 2003; Ottosson, 2003; Koshy, 2010). Action research aims to develop a holistic understanding during a project and to recognise complexity (Gummesson, 2000). It is an iterative process of problem identification, planning, action and evaluation (Argyris et al., 1985; Waterman et al., 2001; Lingard et al., 2008; Koshy, 2010). Action research as a method involves continuous collaboration between the researchers and the client adjusting to new information and events (Gummesson, 2000; Koshy, 2010).

The strength of action research is that it provides the researcher with substantially improved access to data compared to other methods because the researcher is actively involved. The weakness is that the results are not easy to be generalised as they are largely affected by the context of each company.

3.3.2.1.2. Engaged scholarship

This research adopts engaged scholarship language as it provides another way of thinking and communicating about action research.

Earlier in section 3.3.2.1., it was mentioned that engagement is the chosen research procedure. Critical realist action research is well positioned for engaged research, but there is another research design that supports for engaged research, which is engaged scholarship (Ram et al., 2014).

'Engaged scholarship is a participative form of research for obtaining the different perspectives of stakeholders in studying complex problems' (Ram et al., 2014).

Moreover, action research is recognised as one of the four forms of conducting engaged scholarship and critical realism is the underlying philosophy of engaged scholarship (Van de Ven, 2007).

This is an opportunity to use engaged research design elements, as it requires close collaboration between academics and practitioners (Van de Ven and Johnson, 2006). According to Bartunek (2007), practitioners' knowledge often precedes academics. Engaged scholarship is a form of gaining perspective of key stakeholders like researchers and practitioners that enhance the knowledge of both (Van de Ven and Johnson, 2006; Van de Ven, 2007).

Like every research design, the combination of engaged scholarship with action research has nuances and benefits. According to Pfeffer's (2007) vision of management research, having more influence on the actual practice of management in an organisation has two requisites. The first is covered by engaged scholarship and the second is by action research. Engaged scholarship provides engaged connection of the researcher with practitioners. Action research brings the mutual influence over conducted research and the way it is disseminated. On the other hand, McKelvey (2006) highlighted two nuanced differences between action research and engaged scholarship. The differences are that action research does not include (McKelvey, 2006):

- Arbitrage, use of the difference of knowledge between researcher and practitioners to generate new knowledge.
- Big questions, action research focus on individual company's problems, when engaged scholarship examines questions that are in higher level.

Also, McKelvey (2006) critiques engaged scholarship for its:

- Bias. Academic researchers and academic consultants have a conflict of interest, as researchers are driven by scientific ideas, while consultants might be interested in making the customers happy to get the fees.

- Academics are based on disciplines, and that needs time, when practitioners need immediate help, as their process timeline is different.
- Time and site-specific findings cannot be as broad as scientific findings.

Methodologically Van de Ven's (2007) engaged scholarship diamond model (Figure 8) provides a promising research design as:

- Engaged scholarship adopts the critical realist perspective.
- Action research is engaged scholarship's dominant method for conducting research with clients.
- Abduction is engaged scholarship's main logic of discovery.

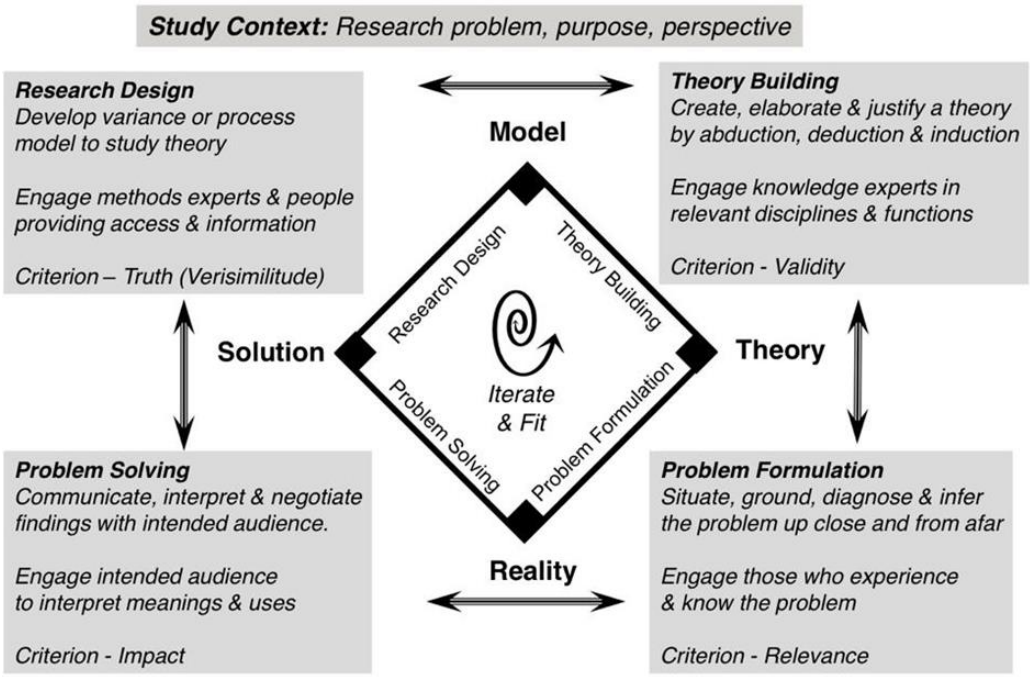


Figure 8. Engaged scholarship diamond model (Van de Ven, 2007).

The diamond model is comprised of four iterative steps (Van de Ven, 2007):

- Problem formulation, grounding the research problem in reality by identifying who, what, where, when, why and how the problem appears. This is achieved through discussions with persons who have knowledge and experience of the problem, and a review of the existing literature.
- Theory building contains discussions with experts on the related topics and functions to the particular problem. All forms of reasoning are used to address the question and develop a theory and its alternatives.

- Research design develops a model for evaluating the theory and its alternative by collecting relevant evidence.
- Problem solving communicates and applies findings to address a problem.

The research options described have strengths and weaknesses that were explored before deciding the appropriate method to conduct this research. Action research influenced by engaged scholarship seems the most suitable choice, as the leadership is in the organisations and must be studied carefully. The coverage of this study will be limited to certain companies as the knowledge state of the research problem does not allow us confidently to use the survey as a method.

3.3.2.1.3. Supportive methods

In addition to action research, other supportive methods to aid data collection and analysis were used and are briefly introduced here.

Literature review

Research should build on existing knowledge as there is always relevant literature to refer to (Karlsson, 2009). Therefore, this research is based on thorough literature review. The main purpose of the literature review is to summarize and interpret relevant research to act as a basis for the proposed research study (Table 11).

Table 11. Reasons to conduct a literature review (Cooper and Blumberg, 2011).

Reasons to conduct a literature review
Establish the context of the problem or topic by reference to previous work
Understand the structure of the problem
Relate theories and ideas to the problem
Identify the relevant variables and relations
Show the reader what has been done previously
Show which theories have been applied to the problems
Show which research designs and methods have been chosen
Rationalise the significance of the problem and the study presented
Synthesize and gain a new perspective on the problem
Show what needs to be done in light of the existing knowledge

Interviews and focus groups

Interview is the main method for collecting qualitative data. Interviews can be conducted as individual or group interviews or focus groups. Interviews aim to discover the views, experiences, beliefs and motivations of individual participants while focus group utilises group dynamics. The aim of the interview is through language data to get insights into

organisational and social contexts. It takes place through the exploration of the views, opinion and perceptions of groups or individuals (Easterby-Smith et al., 2012).

Interviews are believed to provide a better understanding of social phenomena compared to other quantitative methods, like questionnaires. It is the most appropriate choice where there is limited knowledge about the study phenomenon or where in-depth insights are required from participants (Silverman, 2000).

Focus groups main purpose is collecting similar data from many participants at once. It is a group discussion on a particular topic. The discussion is guided by the researcher (Kitzinger, 1994; Morgan, 1998). Focus groups are used for generating information on collective views, and the meanings that lie behind those views (Morgan, 1998).

For this research, the author used a semi-structured interviews and focus groups that included several key questions to define the areas for exploration, but this approach also allowed participants to deviate while the researcher received a more detail response (Britten, 1999).

Cognitive mapping

Cognitive mapping has become a popular technique that encourages creative thinking and problem solving. According to Swan (1997), cognitive maps are considered as: '*internally represented schemas or mental models for particular problem-solving domains that are learned and encoded as a result of an individual's interaction with their environment*' (Swan, 1997).

Semantic theory supports that knowledge has a network layout where concepts are connected (Katz and Fudor, 1963). Constructivist's support that new knowledge is obtained through integrating new information into existing knowledge structures. Network mapping concepts and the described interrelations express how knowledge may be mentally integrated. Cognitive maps can have the form of concept maps and mind maps [Turns et al. (2000); Wheeldon and Faubert (2009); Wycoff (1991)]. For this research concept, maps are more appropriate as mind maps do not have a linear relationship with ideas. Concept maps visualise the relationship among concepts (Plotnick, 1997). They are graphical representations

of concepts and their links. The nodes represent the concepts and the links the interrelationships. (Turns et al., 2000).

According to Bryman and Bell (2011), cognitive maps can help in action research problem-solving while the researcher interacts with managers to address an organisational issue. The mapping process involved participants in identifying factors that affect decision-making, and ideas or concepts are developed based on interviews and focus groups. The result is a map that represents the understanding of the given topic at this time.

3.4. Research design delivery

The researcher briefly explains how he used the diamond model of engaged scholarship (Figure 8) to explore the given research question by conducting case studies following an action research spiral logic.

As mentioned earlier, the researcher used the diamond model that involves four steps:

Regarding problem formulation: the researcher grounded the problem through the use of grey literature (Chapter 1), and answered the following questions:

- Who: the researcher involved sustainability managers and the persons who had to take action on sustainability issues in a company.
- What: the researcher studied the processes of sustainability aspects integration.
- Where: the problem was explored at the most sustainability-advanced parts of two multinational corporations. Their work/initiatives on sustainability traditionally are replicated in the rest of the organization.
- Why: literature analysis showed that strategy and operation levels in practice are often disconnected on the sustainability aspects, and the researcher wanted to study this in the cases. The researcher could find no conceptual framework to better support the integration of sustainability across both strategy and operations levels.
- How: the problem was addressed through conducting case studies involving AR/ES and participating in the corporate sustainability projects.

To address the theoretical aspects, the researcher reviewed existing literature and identified LCM as a promising concept for the chosen problem. However, the literature showed that

LCM was a vague concept, so through analysis the researcher developed three LCM objectives that were explored with a help of the proposed research design. In further iterative cycles, the researcher presented his ideas on the LCM objectives and the related integration factors.

The researcher decided to conduct two action research cases and each case allowed to test the ideas of the researcher on certain LCM objectives. In both studies, the collaboration was established on the shared interest on the companies' internal objective of improving their performance. The researcher joined the team as a researcher that will conduct the key aspects of the analysis and will provide conceptual frameworks that will influence the companies in their decision making regarding their actions on the integration of sustainability aspects in their processes.

The academic target of each case was to participate in corporate projects on sustainability. The first case was a company with a small sustainability group limited in supply chain auditing and the management was interested in establishing intra-organisational processes. This case allowed to explore sustainability analysis and integration management objectives, as both customer and researcher wanted to achieve the same result. The client needed help to establish the processes and the researcher through the project participation enhanced his knowledge of LCM objectives.

The second case was focused on the continuous improvement objective that little is known about. For the second case, the researcher required a company with well-established sustainability group and sustainability processes. The second case company was one of the first companies with a globally established environmental group that existed for more than two decades. The sustainability group had a long tradition and was very advanced on sustainability analysis objective, however, it struggled with the integration management and continuous improvement objectives.

In both studies, the researcher had access to documents, used interviews and focus groups to collect data, and used cognitive mapping to visualize ideas and results to get feedback from the participants.

Proceeding with problem solving, the researcher proposed interventions, and many of those interventions were adopted by the management of case companies to improve the integration of sustainability aspects.

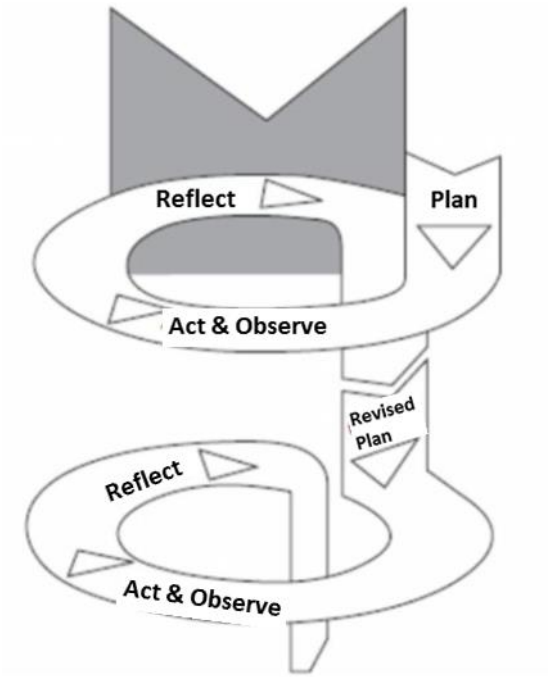


Figure 9. The action research spiral (Kemmis and McTaggart, 2000).

This research followed an action research spiral logic (Figure 9) utilizing the engaged scholarship diamond model (Figure 8). As it is described in research flow of Chapter 1 (Figure 2), we can see two spirals before reaching the research outcome. The problem formulation, research design and concept development are part of the plan aspect of the spiral, the reality tests are part of the act & observe aspect of the spiral while the red line that connects Case A and literature review 2, and the research outcome are parts of the reflect aspect of the spiral.

3.4.1. Clarify the action research and case study aspects of research design delivery

The researcher was invited as an academic consultant to be actively involved in the projects with the aim to provide a new approach on managing the integration of sustainability aspects into organisational processes. The proposed work had similar focus to the work described in the LCM literature (e.g. improve product performance, integrate sustainability information in organisational processes), however, the focus was not to deliberately conduct LCM projects.

In the first case, the researcher had to conduct sustainability analysis and the related hotspots which guided the development of the sustainable program of the business unit. In the second case, the role of the researcher was to provide new analytical techniques that would help the firm in identifying any inefficiencies in the integration of the sustainability strategy in the organisational processes.

In both cases, the companies expected the researcher to be actively involved and provide tools and frameworks that would help the companies decide/adopt LCM related actions. The researcher suggested the use of the frameworks to help them to come up with the actions (in neither case company the researcher suggest actions, but was often involved in discussions about action details). This active engagement with the improvement objective of the case companies is the defining characteristic of action research. As with all action research this brings the benefit of very close and long-term access to the real situation, while also bringing the risk of bias (through desire to help).

The main work/research conducted during these projects was focused to work related to the three LCM objectives (sustainability analysis, integration management and continuous improvement) where the researcher was actively involved. Nevertheless, further data collection on the factors came from participants observation (e.g. LCM factors influence/adoption/appearance) that is similar to conducting a traditional case study, but access to this part of data collection was additional to, and a result of the action research activities.

3.4.2. Data collection and analysis processes

The data collection was a long and time-consuming process that is the reason why the researcher decided to conduct two cases due to time constraints. In case A, the project lasted five years; the ten SAP participants were interviewed multiple times, three focus groups and project observation. In case B, the project lasted two years; fifteen project participants were interviewed – five of them multiple times, two focus groups and project observation.

The projects are based in long and deep observation as both organisations are very complex and understanding their context and familiarization with the company, products, processes and people takes time.

i. The collection methods used were:
   - Document analysis: company reports (sustainability, organisational structure, bill of materials). The reports provided a basic understanding of the organisational processes and structure. The bill of materials provided data for the sustainability analysis.

- Focus groups recordings description: the focus groups were organised in order to bring the different company actors together that are involved in the integration process, this helped to grasp the different perspectives of the integration. The agenda was co-decided between the company's sustainability leader/ project collaborator and the researcher and the team he was part of. Initially the agenda had two parts, the first was related to the partner's needs and the second the researcher's contribution. When the agenda was decided the team that the researcher was part of took the lead.
- Semi-structured interviews with recordings and description: the focus of the interviews was to have a better/ more detailed view of the different actors that have a role in the integration of sustainability in their organisation. The questions were focused on describing the integration process from their own perspectives and then the questions were adapted to the answers (i.e. ask to describe a part that was not clear or worth more investigation – questions about what, how, who, why, when, where).
- Questionnaires (only for LCAs): a series of questionnaires were developed to collect data for the LCAs. Following the information of the bill of materials, the suppliers received questionnaires regarding the production processes that they use.

ii. Data processing – recordings and transcription. The recording transcriptions were conducted manually. This process was conducted by two individuals (the researcher and a friend) in two phases. First, one person was listening to the recordings and typed into a word processor, and in the second phase the other person was listening to the recordings and correcting any transcriptions errors.

iii. Processed data verification. It was arranged that the participants will receive the transcripts and verify the validity of the text. In addition, a large part of the research participants was present in the analysis presentation to provide further feedback.

iv. Data extraction – highlight interesting quotes and cut-out. As described in the literature analysis section, data extraction was a key part of the analysis. Based on the LCM elements and factors identified from the LCM literature analysis, the researcher extracted the quotes that refers to the elements, factors and other

interesting quotes that enhance the knowledge of sustainability integration in organisations.

v. Thematic coding – clusters development

- Develop clusters – clusters are influenced by the ideas stated in chapters 4 and 7 (i.e. LCM processes and LCM objectives), linking the quotes with the related clusters. If something does not fit it is moved to an additional cluster with other quotes that did not fit with the current clusters.
- Develop sub-clusters– they are influenced by the ideas stated in chapters 4 & 7 (i.e. LCM processes sub-clusters: highlighting, collaborating, etc.), linking the quotes with the related sub-clusters. If something does not match it is kept on an additional sub-cluster with the quotes that not fit with the current themes.
- Review the individual sub-clusters including the additional sub-cluster's– rename them if needed, define sub-clusters and divide them into further sub-groups if they can be formed.
- Review the sub-clusters and clusters connections to identify interrelations – cognitive mapping.

vi. Analysis verification.

- At a later stage, ask participants to review analysis and inform the researcher if there are any mistakes or gaps.
- Use third party reviewers for the LCAs.

Appendix 8 provides some examples of data analysis.

3.5. Quality and rigour of the research

The credibility criteria of qualitative research will be addressed in this section. These criteria will be used as lenses on assessing the quality and rigor of this research at the discussion chapter.

Guba (1981) discussed the trustworthiness contrast between the scientific (quantitative) and naturalistic (qualitative) researchers. Quantitative researchers questioned the quality of the qualitative researchers. He proposed four equivalent criteria that fit the naturalistic way of assessing research quality described in Table 12 with possible provisions to ensure quality for each quality factor.

Internal validity is one of the basic traditional criteria and it checks if the study findings make sense and are authentic. The equivalent question for the qualitative researcher is the correspondence of findings with reality (Merriam, 1998).

External validity implies applicability of the study in other circumstances. The outcomes of qualitative research are specific to a small number of participants and therefore, it is questionable if the findings can be applied in other situations. However, it depends on researcher's understanding of the study background to ensure that transfer to another context is valid (Lincoln and Gupta, 1985).

Reliability means that the study can be repeated using the same method, involving the same participants and using context, so the same results will be obtained (Shenton, 2004). Qualitative researchers face a problem because of the changing nature of the addressed phenomena. Lincoln and Gupta (1985) proposed the use of overlapping methods to address this issue.

Objectivity tries to remove the human element (skills and perception) impact on the study. The tests and questionnaires are designed by humans, so the bias element is inevitable (Patton, 1990). For qualitative researchers, the case is to ensure that results come from the participants and not preferences of the researcher (Miles and Huberman, 1994).

Table 12. Traditional and alternative criteria for judging qualitative research *(Shenton, 2004)*.

Traditional criteria for judging quantitative research	**Alternative criteria for judging qualitative research (Guba, 1981) and Possible provision (Shenton, 2004)**	
Internal validity	**Credibility**	Adoption of appropriate, well recognised research methods.
		Development of early familiarity with culture of participating organisations.
		Random sampling of individuals serving as informants.
		Triangulation via use of different methods, different types of informants and different sites.
		Tactics to help ensure honesty in informants.
		Iterative questioning in data collection dialogues.
		Negative case analysis.
		Debriefing sessions between researcher and superiors.
		Peer scrutiny of project.
		Use of "reflective commentary".
		Description of background, qualifications and experience of the researcher.
		Member checks of data collected and interpretations/theories formed.
		Thick description of phenomenon under scrutiny.
		Examination of previous research to frame findings.
External validity	**Transferability**	Provision of background data to establish context of study and detailed description of phenomenon in question to allow comparisons to be made.
Reliability	**Dependability**	Employment of "overlapping methods".
		In-depth methodological description to allow study to be repeated.
Objectivity	**Confirmability**	Triangulation to reduce effect of investigator bias.
		Admission of researcher's beliefs and assumptions.
		Recognition of shortcomings in study's methods and their potential effects.
		In-depth methodological description to allow integrity of research results to be scrutinised.
		Use of diagrams to demonstrate "audit trail".

As action research is the chosen research method, the quality and rigour points of Table 13 will also be addressed.

Table 13. Quality and rigor in action research (Reason, 2006; Coghlan and Brannick ,2014.(

Quality	Is the action research explicit in developing a praxis of relational participation? In other words, how well does the action research reflect the cooperation between the action researcher and the members of the organisation ?
	Is action research guided by a reflexive concern for practical outcomes? Is the action project governed by constant and iterative reflection as part of the process of organisational change or improvement?
	Does action research include a plurality of knowing which ensures conceptual-theoretical integrity, extends our ways of knowing and has a methodological appropriateness? Action research is inclusive of practical, propositional, presentational and experiential knowing and so as a methodology is appropriate to furthering knowledge on different levels.
	Does action research engage in significant work? The significance of the project is an important quality in action research.
	Does the action research result in new and enduring infrastructures? In other words, does sustainable change come out of the project?
Rigor	How you engaged in the steps of multiple and repetitious action research cycles (how constructing, planning, taking action and evaluating were done) and how these were recorded to reflect that they are a true representation of what was studied.
	How you challenged and tested your own assumptions and interpretations of what was happening continuously through the project by means of content, process and premise reflection, so that your familiarity with and closeness to the issues are exposed to critique.
	How you accessed different views of what was happening which probably produced both confirming and contradictory interpretations.
	How your interpretations are grounded in scholarly theory, rigorously applied, and how project outcomes are challenged, supported or disconfirmed in terms of the theories underpinning those interpretations and judgements.

3.5. Summary

Through this chapter, the research paradigms were discussed and linked with the research question. As described in Figure 10, the researcher made some decisions on the way this research was conducted. The researcher decided that critical realism is the paradigm that will guide this research. Having in mind that this research is influenced by critical realism, the design options were explored and the researcher explained his choice of action research influenced by engaged scholarship. Also, this chapter introduced research design strategy and research quality criteria that will be used to assess this research during the discussion (Chapter 9).

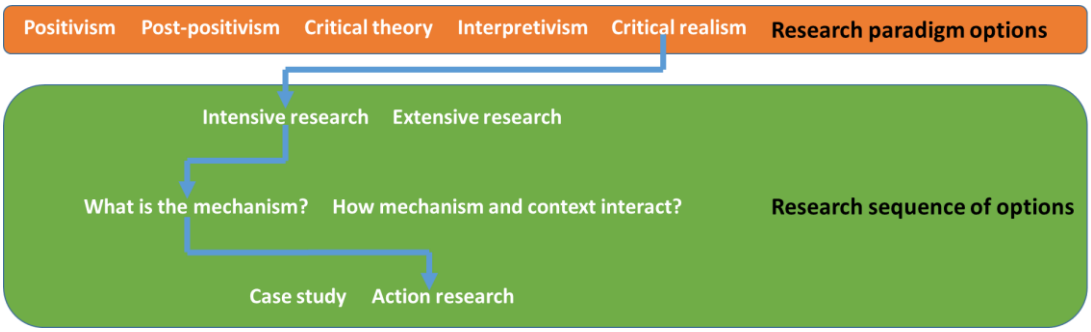


Figure 10. Research method decisions flow.

4. First conceptual framing

This chapter uses the LCM literature to develop concepts and frameworks that guide the first case with the aim that the obtained knowledge will contribute to practice and research.

4.1. LCM conceptual framework

Having reviewed the literature, the researcher introduces his observations on the development of an LCM conceptual framework.

The researcher had to make choices regarding concepts that would drive this research. As it was earlier discussed in Chapter 2, the vast majority of LCM literature focuses on:

- holistic VC standpoint,
- sustainability analysis objective,
- lifecycle thinking approach,
- LCA tools.

The researcher believes that all these elements play an important part in LCM, however, they do not reflect the whole LCM concept. This research will focus on the Actor of the VC standpoint while putting emphasis on all three LCM objectives and the intra-organisational aspect of LCM.

The LCM literature talks a lot about supply chain management (SCM) through the inter-organisational management. However, the researcher thinks it is also important to understand the intra-organisational factors of integrating sustainability before trying to explore the inter-organisational ones, as the decisions in the company are taken at the intra-organisational aspect.

The LCM literature overemphasizes the sustainability analysis objective that also relates to holistic VC standpoint. The researcher wants to explore the process of how this information is utilised in the organisational processes.

In the literature some researchers point to PLM as one of the approaches to enhance the utilization of the information in the organisational processes. The researcher accepts that the integration process has more dimensions than the linear distribution of information and it has more aspects that are going to be introduced in this chapter.

The decisions regarding LCM approach made in this chapter will guide this research. Later, the researcher will reflect whether, and how much, these decisions were beneficial as proposed concepts/frameworks.

4.1.1. Context

As it became apparent from the literature review the concept of LCM as an organisational process requires more clarity, while corporate LCM cases should be explored in more detail.

For this researcher, LCM is a management concept that allows to integrate sustainability within the organisation. Building up on the existing LCM literature, the author proposed the following definition:

LCM is a management concept that aims at integrating sustainability-related information to organisational processes in order to enhance the sustainability performance of the organisation and its value chain.

The author also would like to provide a broader description of the concept:

LCM brings clarity to the process of integrating sustainability-related information into organisational processes. The purpose of LCM is to help managers that have to address or manage the integration of sustainability aspects in a company and its value chain. LCM spreads to all organisational levels where sustainability-related information is integrated in decision-making process, and this can happen both horizontally and vertically. On the horizontal axis (same organsational level), the intra-organisational part of the company is the core of LCM. While the inter-organisational is the satellite relationships of the company, that cannot be controlled directly. On the vertical axis (different organisational level) LCM is a conceptual framework that consists of factors that influence the integration of sustainability in organisational processes. The knowledge of these factors can help managers plan the initiation, establishment and development of the integration.

4.1.2. Concept

A set of LCM objectives and related factors have been recognised by the researcher based on literature analysis and his ideas.

The researcher aims to develop a conceptual framework to help managers who have to address or manage the integration of sustainability aspects in a company.

The framework consists of the objectives and related factors that influence the integration of sustainability aspects in organisational processes.

The researcher believes that LCM fulfills three objectives.

- The sustainability analysis objective that allows to evaluate the given condition, to identify and to provide information on sustainability risks and opportunities to non-experts.
- The integration management objective that aims to integrate the sustainability-related information within the organisational processes and to inform decision-making process.
- The continuous improvement objective that intents to set up the integration of sustainability-related information in organisational processes and to improve integration continually.

Based on the case analysis of the LCM literature the researcher proposed eight factors that are described in Table 14 and could influence the integration of sustainability aspects in organisational processes. Each factor can relate to all three LCM objectives. All factors can be linked to both intra- and inter-organisational partners. The LCM process starts with highlighting the need for considering sustainability-related information and finishes with either implementing, sustaining or developing knowledge on a project or a process, but the in-between sequence of the process steps could vary.

The factors were developed through application of a ‘filter’ focused on management view of bringing change about sustainability. This filter allowed the researcher to group collected references and to develop eight LCM factors.

The factors stated in Table 14 will provide a basis for the analysis of the first stream of cases. As there is no space to explain all of them, the researcher will focus on the most common

factor that is decision-making, that is mentioned in the majority of cases. Yet, none of the papers pointed to the decision-making quality importance.

Table 14. LCM factors.

Factors	Description	Examples in cases
Highlighting	Emphasis/trigger to integrate/address sustainability aspects in organisational processes.	The high waste disposal cost mentioned by Hunkeler (2004a).
		The automotive customers warned to penalise companies that use only virgin materials (Hunkeler, 2004a).
Collaborating	Initiate cooperation with parties that have an interest in the integration of the sustainability aspects.	Set up cross functional projects (Holgaard et al., 2007).
		Work with distributors to reduce the impact of logistics (Holgaard et al., 2007).
Analysing	Study current implementation and identify risks and opportunities related to sustainability aspects.	Development of a product sustainability tool that covers the development function (Ford, UNEP/SETAC, 2009)
		Local university conducts an LCA for the case company (Finkbeiner, 2004).
Strategising	Provide direction on the results to be achieved.	Develop technologies that reduce CO2 emissions (Warsen et al. 2013)
		Target to reduce emissions of the value chain by half by 2020 (Unger and King, 2013).
Decision-making	Make choices based on alternative options to deliver the strategy. A decision made at a higher organisational level can be a strategy for the lower organisational levels.	After the assessment they decided to reuse 2/3 of the raw material while remaining 1/3 to sell as by-product for carpet industry (Hunkeler, 2004a).
		Use environmental information in the assessment of purchasing options (Finkbeiner, 2004).
Implementing	Implement a decision or a strategy.	Developed a strategy to reduce water consumption and managed to achieve 43% less water use by 2000 (Bligny et al., 2013).
		Conduct an ICM project with suppliers in Chile (Emhart et al., 2013).
Sustaining	Convert certain aspects of a project to an organisational or operational process.	3M mentioned that have run LCM multiple times; they adopted LCM as a process (Fretiere, 2001).
		Work very closely with customers on the sustainability of their products, made it a process (Alcan, UNEP/ SETAC, 2009).
Developing knowledge	Learn from experience and use knowledge to improve and to expand the existing processes to achieve better results.	Establish working groups exchanging experience (Holgaard et al., 2007).
		Provide a report to suppliers with their results and recommendations (Uebelhoer et al., 2013).

At this stage, the emphasis is more on sustainability analysis and integration management objectives as the continuous improvement objective builds on the knowledge of current analysis and the intra-organisational managerial setting. The following discussion focuses

more on two objectives, i.e. sustainability analysis and integration management, while the continuous improvement objective is emphasised in Chapter 7.

4.2. LCM Sustainability Analysis Objective

The study of the sustainability analysis literature helped to conceptualise the observed sustainability-related information layers and flows across the VC.

The sustainability analysis objective is related to sustainability assessment of products and processes, and it is usually managed by sustainability professionals. The obtained information from the sustainability analysis is the 'raw materials' of LCM. LCM's main emphasis is on product level because this dimension spans across the value chain. However, the value chain is more complex, since it includes multiple layers providing risks and opportunities for corporate sustainability.

The researcher believes that it is important to explore these dimensions before suggesting tools or systems for integration.

4.2.1. Info-diversity

Figure 11 provides a description of three different impact dimensions [product-process-place] across the lifecycle of a product. Product and production processes approach is inspired by Labuschagne and Brent (2005), who pointed out the difference between product and production processes/asset lifecycles. The product's lifecycle flows along the value chain (red arrow). It starts at resource extraction (or when the material renews its life through end-of-life management) and includes the resources' transition to useful raw material, product, waste and end-of-life option. The processes lifecycle (yellow boxes) contains the production processes that transform the materials to products, the use phase processes and end-of-life processes. In addition, the process lifecycle includes the processes' inputs and outputs. The processes lifecycle is linked with the locations where product lifecycle stages are taking place. The Place approach (grey boxes) was derived from Potting and Hauschild (1997), who mentioned that the unique situation at each location impacts the same exposure in different ways. Environmental, economic and social situation in each location triggers different reactions in each activity. The three dimensions are linked with different types of risks and

opportunities, and analysis of each dimension provides diverse information that would allow to make informed decisions.

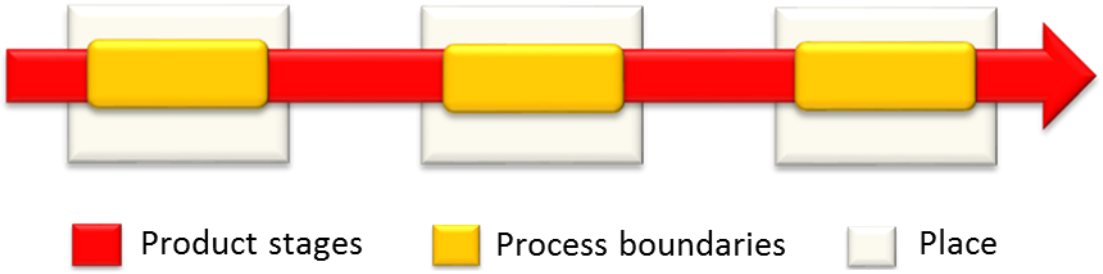


Figure 11. Product–Production processes– Place [3Ps] approach across the VC (Mastoris et al., 2013).

The diversity of information motivated the researcher to develop the info-diversity concept (Figure 12). The info-diversity concept is inspired by Rebitzer and Hunkeler's (2003) framework on LCC and Jensen and Remmen's (2006) framework on product chain collaboration. In the following section, the researcher focuses on how the obtained information can support decision-making process, using the Product–Production processes–Place [3Ps] approach.

Figure 12 has potential of providing many other pieces of information which will emerge through the rest of the thesis. The diagram is richer than text. For instance, the focal company sometimes is the product manufacturer, but it can focus more on cost reductions than other flows or specific parts of the VC. Also, the existence of three different boundaries (Figure 12) on the vertical flows (LCC, LCA and SLCA) and their interaction with specific VC (horizontal flows) shown with vertical arrows do not point to a specific part of the VC, but to the whole value chain.

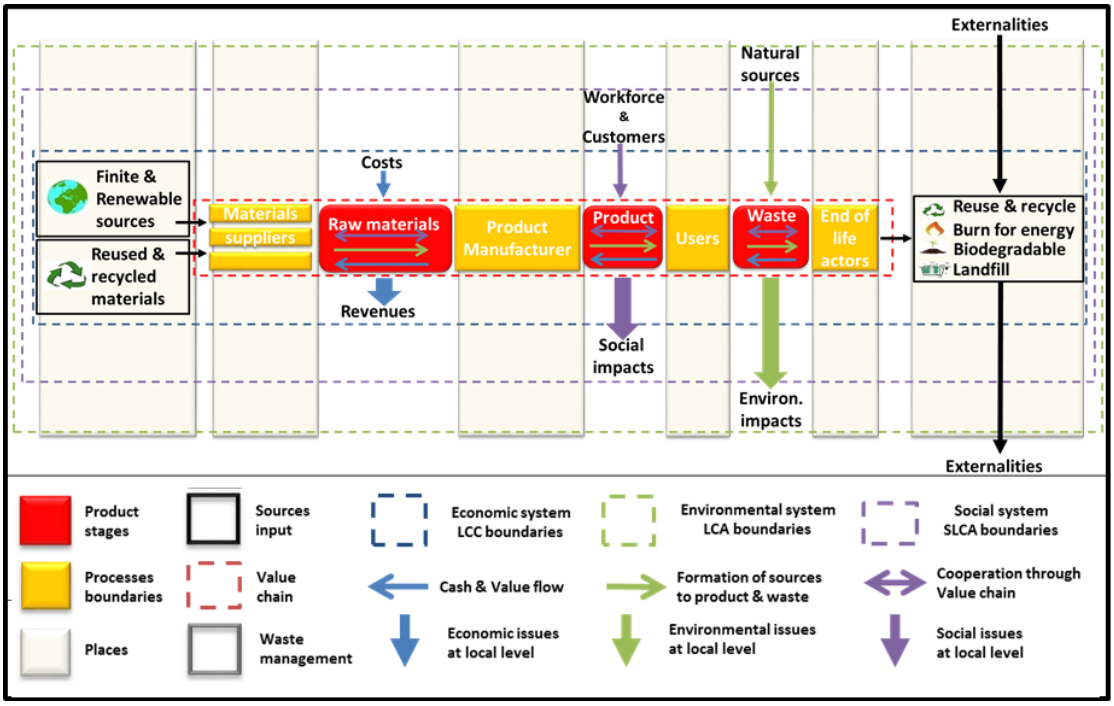


Figure 12. Info-diversity concept (Mastoris et al., 2013).

As described in Figure 12, the value chain has horizontal and vertical flows. The horizontal flows are aligned with the product flow and have three aspects related to inter-organisational cooperation, including:

- the gradual formation of raw materials to product and then waste,
- the cash and value flow from the upstream to the downstream side, and
- the cooperation among the actors to make the flows more efficient.

The vertical flows are linked with each value chain stage and have three aspects related to intra-organisational cooperation, including

- profit (revenues mines costs),
- social impacts, and
- environmental impacts.

The performance of each vertical and horizontal flow can be compared to the performance of an equivalent reference flow or an alternative scenario, and this comparison allows to identify individual risks and opportunities. The addition of economic and social aspects in the traditional LCA is also described in Figure 67 in the transition from traditional to stakeholder based LCA. This process of analysis can help to prioritise action towards identified risks and opportunities: the potential of each alternative scenario should be compared and the actions need to be taken according to availability of resources.

The sustainability-related information across the value chain is very diverse and can support different decisions. The decisions can have intra- or inter-organisational coverage. For example, a decision/improvement that does not affect the rest of the value chain actors or product chain stages has intra-organisational coverage (having exactly the same output, but with less input). If the decision affects the processes or performance of other actors, it has inter-organisational coverage.

Sometimes attempted improvements at one part of the value chain could cause rebound effects to other parts. Therefore, the organisation and the most important stakeholders have to consider potential rebound effects for the organisation and the affected actors in the value chain.

Reviewing the flows in Figure 12, the researcher realised that vertical flows (LCA, LCC, SLCA) represent impacts and costs that reflect 3Ps issues across the VC and link to sustainability analysis (objective 1). Whereas, the horizontal are inter-organisational flows that link to intra-organisational integration management and continuous improvement (objectives 2 and 3) represent business decisions at individual stages of the VC influenced by vertical and horizontal information flows.

4.2.2. Lifecycle Sustainability Assessment (LCSA)

The integration of lifecycle tools was proposed by Finkbeiner (2011) in order to aid decision-making process. However, in some cases provided integrated information does not help decision-making.

4.2.2.1. LCSA challenges

LCSA is a potentially useful contribution to sustainability practice because it provides a tool, which aims to support decision-making by including three different types of analysis as part of the same 'equation'. However, the action of integration faces a number of theoretical and practical challenges. And the efficient use of LCSA requires application of the tools concurrently in the same context. Table 15 provides description of the differences between the tools.

O'Brien et al. (1996) and Norris (2001) described the different approach of social and economic tools compared to environmental tools. Klopffer and Heinrich (2002) expressed their concerns regarding the ambiguity of applying the tools together. According to the Klopffer and Heinrich (2002), the most serious problem is that different lifecycle tools have to use the same system boundaries in order to provide compatible results.

Table 15. Differences between LCA, LCC & SLCA (Mastoris et al., 2012). Derived from O'Brien et al., 1996; Norris, 2001; Benoit et al., 2009.

	LCA	LCC	SLCA
Purpose	Measure environmental performance	Identify cost- effectiveness of investments	Measure social performance
Flows	Pollutants, resources, energy	Costs	Working hours, working accidents, local employment, fair competition, SU, corruption, supplier relationships, etc.
Units	Physical units	Monetary units	Social units
Nature of data	Derived by researchers using primary and secondary data	Financial are provided by operators, environmental and social related are derived by researchers using primary and secondary data	Derived by researchers using primary and secondary data
Time perspective	Not critical, usually 100 years' time horizon.	Very critical, the value of costing units is continually changing	Not critical, usually 1, 5, 10 years horizon; impact dependent
System boundaries	Raw materials to EoL	Product R&D to EoL	Raw materials to EoL

4.2.2.2. Attempted LC-tools integration in the literature

This section contains an analysis of the academic literature that is focused on the integration of at least two of the following tools Environmental Lifecycle Assessment (LCA), Lifecycle Costing (LCC) and Social Lifecycle Assessment (SLCA). Table 16 contains the papers that addressed the integration of at least 2 out of the 3 LCA tools. The table categorises papers according to the tools that were considered for integration.

Table 16. Papers selected for analysis (Mastoris et al., 2012).

LCA + LCC		LCA + SLCA		LCSA = LCA + LCC + SLCA	
1	Guinée et al., 2006.	7	O'Brien et al., 1996.	13	Schmidt et al., 2004.
2	Corti et al., 2009.	8	Gauthier, 2005.	14	Buchholz et al., 2008
3	Lyrstedt, 2005.	9	Labuschagne et al., 2005.	15	Finkbeiner et al., 2010.
4	Sundin et al., 2011.	10	Franze and Ciroth, 2011.	16	Peri et al., 2011.
5	Yamaguchi et al., 2007.	11	Franze and Ciroth, 2011.	17	Vinyes et al., 2011.
6	Reich, 2005.	12	Weidema, 2006.	18	Capitano et al., 2011.

It appears that there is a number of distinct approaches to the integration of lifecycle results. Some studies apply concurrent lifecycle perspectives but do not attempt to integrate the

evaluation of the results and discuss the results separately. At the same time, those who have attempted integration followed one of two paths, which are outlined in Figure 13.

Multi-dimensional approach is the first path, where each impact/cost identified by the individual lifecycle tool is considered in parallel with the individual results of the other lifecycle tool(s) under consideration. In majority of the cases this path keeps each impact/cost separate and retains their original units (i.e. Kg of CO2, $ and accidents). In the remaining cases the further analysis of the results provides an opportunity to translate them into a common unit, so they may be compared on an equal footing.

Single-dimensional approach is the second path, which gradually integrates the results of each lifecycle tool by combining the results from a single lifecycle tool into a single measure and then combines these measures into a single result for a given sustainability pillar. These results are then integrated into one number (direct integration) or arranged into representation, which describes the 'sustainability' balance of the situation under consideration (described balance).

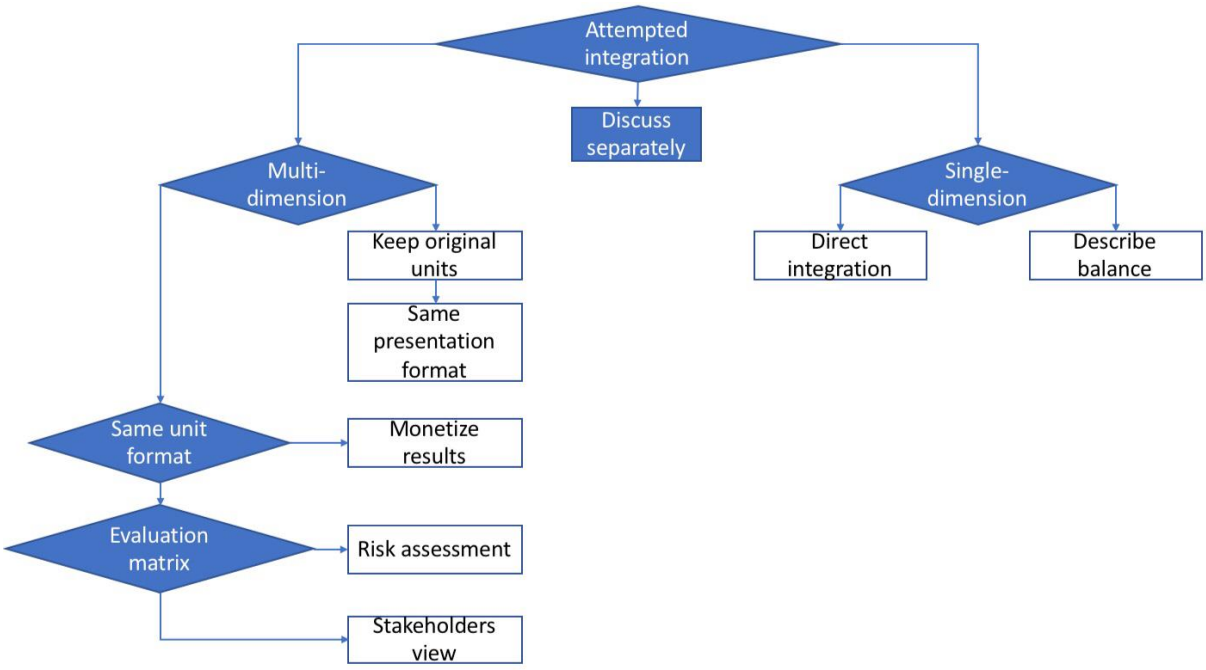


Figure 13. Integration paths (Mastoris et al., 2012).

For each company the information flows vary and therefore, different organisational units get involved in the decision-making process. Also across the organisational levels, the needed information details are different and the considered aspects are not the same. Better

understanding of this unexplored variability will help in development of an LCM concept that could be adjusted to each company's unique conditions.

4.3. LCM integration management objective

The adoption of management related literature helped to introduce organisational management concepts to enhance the integration management objective and explore the similarities, links and differences with sustainability analysis objective.

The integration management objective is related to the integration of sustainability-related information in organisational processes, and it is usually managed by the assigned task managers. The information obtained through the sustainability analysis part of LCM needs to be directed to the interested intra-organisational parties and to be integrated in the different organisational processes.

Existing literature does not adequately cover the intra-organisational part of LCM. For example, Schmidt (2013) mentioned that product management system is supported by numerous tools without focusing on the important aspect of the social practices of the employees when they put LCM in place.

4.3.1. LCM and LCT at the organisational context

As a management term, LCM was firstly introduced by King and Cleland (1988). According to them: *'Lifecycle management refers to the management of systems, products, or projects throughout their lifecycle. …, lifecycle management is needed because the lifecycle reflects very different management requirements at its various stages. The traditional hierarchical organisation is not designed to cope with the constantly changing requirements dictated by lifecycles. It is established to effectively direct and control a much less dynamic milieu'.*

In this particular definition, 'systems' refer to established organisational processes, while products imply products' market lifecycle. Within the organisational context, systems and products are repetitive projects (i.e. processes). This particular definition reflects the perception of lifecycle thinking (LCT) at the organisational level.

Based on the literature analysis, the researcher distinguished three LCT types at the organisational level. The first two have intra-organisational orientation and the last has inter-organisational.

Corporate lifecycle is the first LCT type, introduced by Chapman and Ashton (1914) when they described the development and decline of textile industrial companies in England. According to corporate lifecycle, each organisation has its own lifecycle path that spans from birth to death phase; while growth, maturity and decline phases are the intermediate options (Schwenker and Muller-Dofel, 2013). For an organisation the main aim is to avoid death and to remain at the growth phase for as long as it is possible.

Various organisational processes that relate to the product market lifecycle represent the second type of LCT. Introduced by Levitt (1965), the product market lifecycle refers to the sales performance (longitudinal volume) of a product and it has the same lifecycle stages (development, growth, maturity, revival and decline) as the corporate lifecycle. In order for a company to plan and deliver a product market lifecycle, various intra- and inter-organisational process/projects have to take place from design phase to sales. This concept focuses primarily on the intra-organisational cooperation. Sales is the result of the organisational processes (mechanisms) that collectively aim to increase the performance of products market lifecycle.

Product market lifecycle focuses on one product at a time and the corporate lifecycle focuses on the range of products offered by the corporation. The summary of the individual products' performance offered by a company dictate the organisational lifecycle phase state. Successful product market lifecycle management keeps the corporation at a growth or maturity level, otherwise the corporation is closer to the revival or decline phases.

Product's lifecycle is the third LCT type, and its focus is wider than the boundaries of the organisation since it involves the value chain actors. Each product related project/process usually implies cooperation with the upstream and downstream value chain actors. Therefore, the third LCT type focuses on inter-organisational cooperation. The cooperation of the actors along the value chain is a matter of the influence that the interaction will have in keeping each actor closer to the growth phase.

The incorporation of sustainability aspects in corporate decision-making relates to both intra- and inter-organisational processes. The intra-organisational part narrates to the integration

of sustainability aspects in organisational processes that relate to the Market LC. The inter-organisational part looks at the influence of the decisions on the sustainability of the value chain and the actors' willingness to cooperate on sustainability issues.

The intra-organisational part (market LC/organisational processes) is a cyclical process from both perspectives, whereas the inter-organisational (product LC stages) part is linear and a result of connection of intra-organisational processes along VC. Even despite the fact that corporate (organisational) LC helps to describe the difference between Market and Product lifecycles, the author thinks that corporate (organisational) LC level and perspective cannot be applied in this research as a product LC is usually a tiny part of the corporate LC time frame.

4.3.2. Business processes and sustainability differences

Working on sustainability aspects is fundamentally different compared to working on other aspects of the organisation (Epstein and Buhovac, 2014). Table 17 describes the philosophical differences between sustainability and business development. Project management is a core business methodology, and in an organisation lots of projects or processes (repetitive projects) are taking place simultaneously and allow the organisation to operate. LCM is a process usually run by the sustainability group, but its information outcomes provide inputs for other processes run by other organisational groups.

Table 17. The contrast between the concepts of sustainable development and projects (Silvius et al., 2012; Epstein and Buhovac, 2014).

	Sustainable development	**Business development**
Work for	Future generations	Stakeholders
Orientation	Lifecycle	Deliverables
Focus	People, planet, profit	Business scope, time, budget, profit
Measurements	Often uncertain, long term	Clear, measurable, short and medium term

Projects/processes are focused on keeping the company commercially successful, whereas LCM ensures this success follows the principles of sustainable development. Projects/processes are focused on the business aspect of triple bottom line and LCM tries to improve the alignment of the business aspect with the environmental and social aspects. LCM

as described by the UNEP/SETAC lifecycle initiative is an add-on project that should be aligned with the other company's processes, however, the philosophy is different.

The sustainability group is a supportive organisational group and belongs to the organisational processes level (Figure 14). And as long as there is a philosophical gap between sustainable development and business development, except for the vertical organisational levels gap, a horizontal gap will also be present between sustainability group and the rest of the groups at the organisational processes level. Mintzberg (1979) quite well incorporates both horizontal and vertical gaps into his model.

Figure 14 based on Mintzberg's model describes the relation between the main part of the organisation (strategic apex, middle line, and operating core) and the supportive part (techno structure and support staff). The researcher thinks that LCM objectives are aligned with the main and supportive parts of the organisational processes level on sustainable development. The technocratic part links with the sustainability analysis objective. The integration management part relates to integrating sustainability-related information in organisational processes. The last and most important is the continuous improvement objective where the sustainability-related support staff strives to bridge the philosophical gap. It can be concluded that LCM is a cyclical organisational process with gradually increasing complexity as sustainability-related knowledge and processes become more advanced.

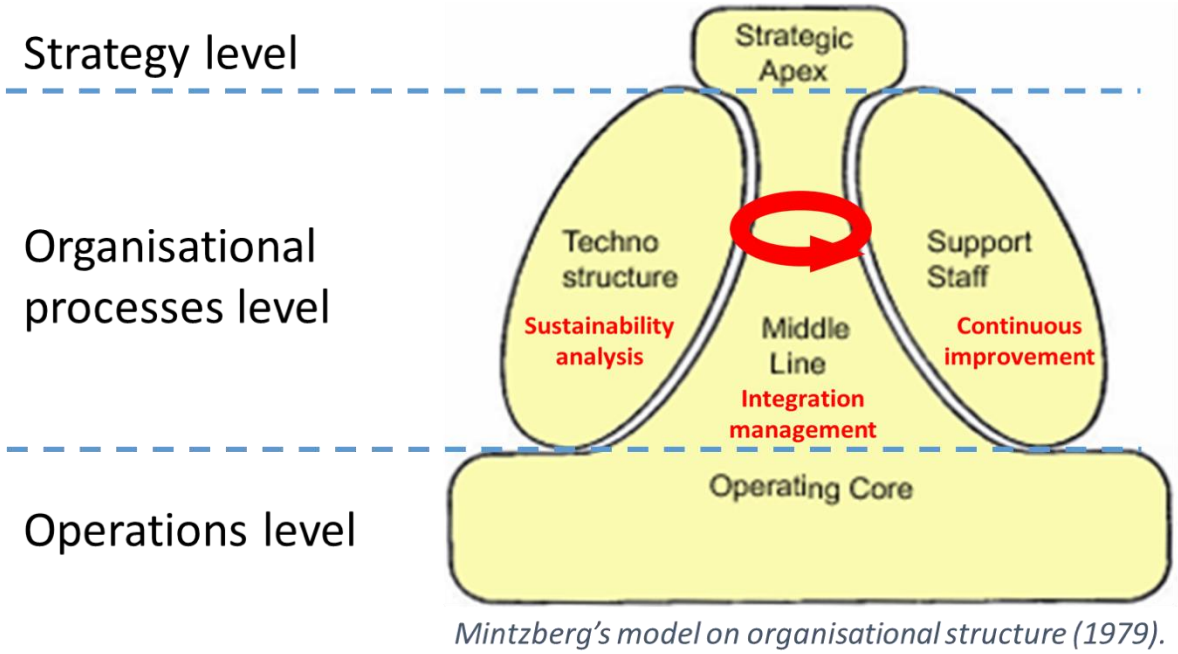


Figure 14. Organisational structure and levels, and the link with the LCM objectives at the organisational processes level.

The link of the organisational processes with LCM is not adequately explored by LCM researchers. The exploration of this link would provide understanding on how to make LCM more adaptable to the way the company operates. Those links will be explored in the following section with a help of information complexity and information cycle concepts.

4.3.3. Information complexity and information cycle

The organisation runs through the various functional processes/projects that operate simultaneously or sequentially. The integration management objective of LCM focuses on integrating the sustainability-related information in organisational processes/projects.

LCM is a system that manages sustainability-related information to support decision-making of the functions (’organisantional groups’) that make and implement these decisions. As described in Figure 15, the information flow complexity usually spans across the three organisational levels and has a cyclical flow.

The cycle starts from the operations level, as the action that takes place across the value chain produces data and the related information are fed to the sustainability group (orange color) at the organisational processes level and this is the end of the sustainability analysis part.

The integration management part usually continues by informing the strategy level on the hotspots (’identified most prominent negative impacts’) of the sustainability analysis and potential actions, the executives provide directions for the sustainability strategy to the sustainability function.

Then the sustainability group informs the rest of the organisational groups (main part of info-complexity). The sustainability group (or professional integrated in a non-sustainability group) level, where the company’s sustainability-related information is collected, analysed, condensed and distribute specific information for the variable groups decisions they need to inform. They receive the sustainability-related information that need to consider in their decision-making process to influence action at the operations level.

Sustainability-related information is incorporated in decision-making process, which implies the cooperation with intra-organisational group(s) and/or value chain actor(s).

The info-cycle concept, that was described in Figure 15, attempts to map the sustainability-related information cycle from lifecycle tools raw information to the actions it may affect in an organisation. The flow of sustainability information in the organisation triggered the concept of info-cycle. The results of sustainability analysis generate information that gives knowledge to the sustainability group about the product's lifecycle issues. The sustainability group informs the executive board about the hotspots and possible solutions. The strategy people determine the direction and criteria towards sustainability. The sustainability group then interacts with the other groups informing their decisions yielding actions that will improve the overall performance of the product's lifecycle. The researcher believes that the info-cycle concept relates to the continuous improvement objective, however, he will expand on this after getting more knowledge through Chapter 5.

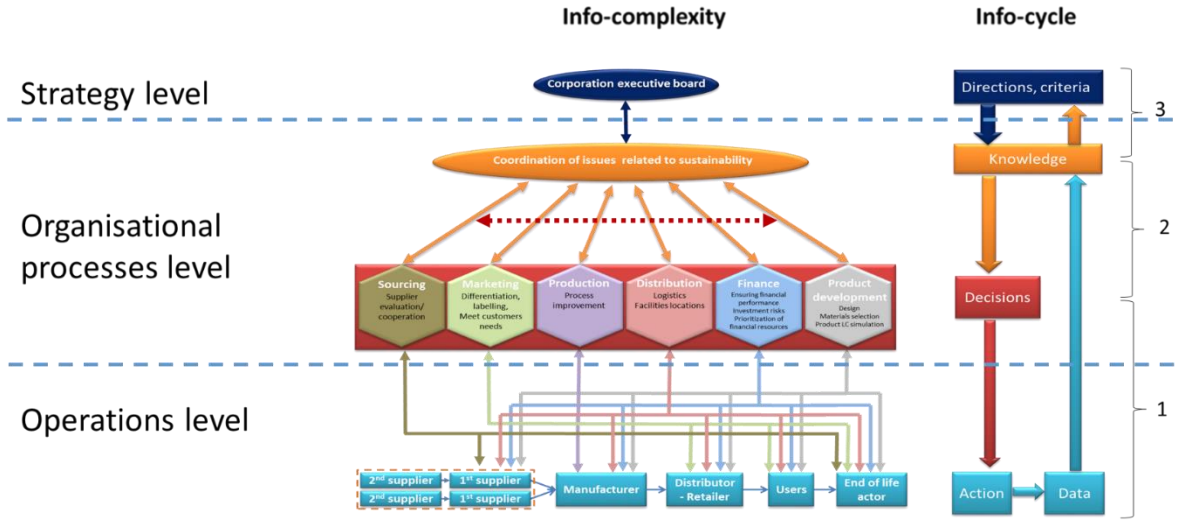


Figure 15. Info-complexity concept and Info-cycle concept (Mastoris et al., 2013).

It is very important to consider the complexity of the company that will use LCM to inform their decisions. As the sustainability aspects are an add-on for decision-making process of each function, LCM needs to adapt to this complexity to support the decision-making process.

4.3.4. Differences and links between sustainability analysis and integration management objectives

First, the sustainability analysis objective is focused on the linear process (product, production and location dimensions), while the integration management (objective) aims at the circular process of organisational management.

Second, the objectives are directed at different types of integration. In case of sustainability analysis lifecycle tools such as LCA, LCC and SLCA are integrated with differing system boundaries, whereas in case of the integration management the sustainability information is integrated with other types of information that are based on a different philosophy.

Nevertheless, these two objectives are closely linked, because the information produced by sustainability analysis has to fit the complexity of the intra-organisational processes in order to ease the integration of the information in the processes.

These aspects require further exploration in practice to find possible pathways to effective integration of lifecycle information into decision-making processes.

5. Initial case

This chapter uses the researcher's conceptual framing introduced in Chapter 4 to analyse a case of integration of sustainability into organisational processes. With the help of the study the researcher will explore the application of the eight LCM factors. In addition, the chapter analyses the relationship between two of the three LCM objectives, sustainability analysis and integration management, through this case.

5.1. Introduction to the case

Multinational brand A develops apparel as well as other products. This case focuses only on the apparel business unit and the development of sustainability processes in apparel's organisational processes. As a result of an increase in sustainability awareness in the apparel industry, the brand decided to initiate their sustainable apparel programme (SAP) to enhance their sustainability performance and to keep up with the industry and market trend. However, the brand had a small sustainability group (SG) with limited abilities to develop innovative projects, and this did not allow them to initiate this programme without external support.

The SG Head for Europe, Middle East and Africa (EMEA) region initiated development of the SAP and enlisted the Centre for Industrial Sustainability (CIS) of the University of Cambridge as academic collaborators for this programme. The collaboration was founded under the clear principles to improve organisational performance, to reduce costs and to improve profitability, whilst conducting work that is of academic interest. The researcher participated in this programme as a member of the CIS team.

Since sustainability aspects were not being addressed in a structured way, the brand initiated the SAP to integrate sustainability thinking into existing organisational processes (from design and development to supplier interaction) and eventually to address activities at the level of brand and business model. Compared to the cases found in the literature this case provides a more detailed overview of an LCM project and reinforces certain aspects addressed in other LCM cases or adds new knowledge.

5.2. Case coverage

This section provides a description of the structure of the company and introduces the case.

5.2.1. The organisational structure and organisational levels

At the time of the project initiation, the brand had a divisional organisational structure where each geographical division was an autonomous branch managing the market of the area under the global structure. Each region had three business units, including the apparel business unit. Each business unit had its core organisational groups that were endorsed by the supportive groups of the region. Like most of the apparel brands, brand A did not own manufacturing facilities, and the production was assigned to specialised contractor manufacturers.

In order to have a good understanding of the organisation, the researcher analysed all available documents and addressed specific questions to the case partner (SG Head). Cognitive mapping was used to represent the researcher's interpretation of the organisational structure and levels. Moreover, the researcher asked many of the participants to make comments about the map. Figure 16 describes the researcher's interpretation of the brand's organisational structure and levels. In particular, the map looks into two aspects that were earlier discussed in Chapter 4:

- Sustainability group (SG) usually plays a supportive role, and the example of brand A follows this norm.
- Sustainability integration processes take place at the organisational processes level.

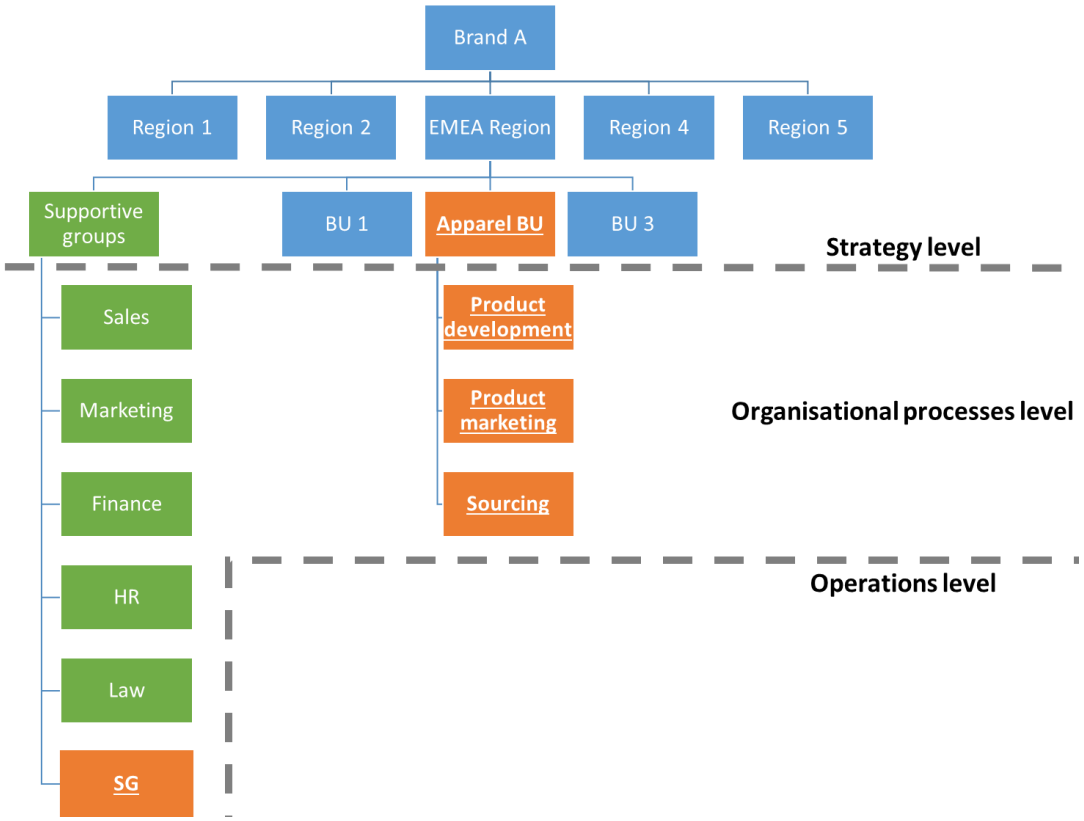


Figure 16. Brand A organisational structure and levels.

5.2.2. SAP coverage

The case analysis was focused on the organisational processes level and orange boxes in Figure 16, which shows the extent of the coverage of this case. The blue boxes of the diagram are parts of the organisation (regions and business units) that were not examined in this case. The green boxes represent the supportive functions of the EMEA region while the rest of the figure describes core parts of the organisation. The supportive groups except for the apparel business unit serve BU1 and BU3, but these parts of the organisational structure were not considered in this study.

The EMEA SG Head proposed this project to the executive board of brand A and received the approval to start this project with a focus on the EMEA apparel business unit. Most of the cases in LCM literature describe the whole organisation without organisational structure distinctions. The more detailed focus of this case will help the researcher to be more precise and descriptive.

5.2.3. SAP timeline

The program had a five-year timeline. As described in Figure 17 SAP had four stages. During the Background Stage at the end of 2010 the partners of the programme developed an initial plan for SAP. However, the programme commenced in September 2012, and the initial plan involved two sequential stages with an option to extend. The first stage (Stage I) of this project sought to integrate key sustainability considerations into design and development processes. The second stage (in case the results of the first stage support it) was intended to support manufacturing and sourcing in integrating sustainability into their decision-making process. The programme was extended (third stage) and further developed as more knowledge was acquired and lasted until the autumn of 2015.

The scale of the project required involvement of a team of researchers. Due to the length of the project the role of the researcher changed over time: the researcher participated in the Background Stage, he was the main researcher in Stage I and had a less active role in Stages II and III, and had an active role again at the closing of SAP.

During the SAP timeline, the CIS team was the only permanent external partner. NU an academic institute that is specialised in fashion design management and was a partner during the Background Stage and Stage I. Quantis an international LCA consultancy was involved during Stage II along with one first-tier and two second-tier suppliers that also participated in Stage III.

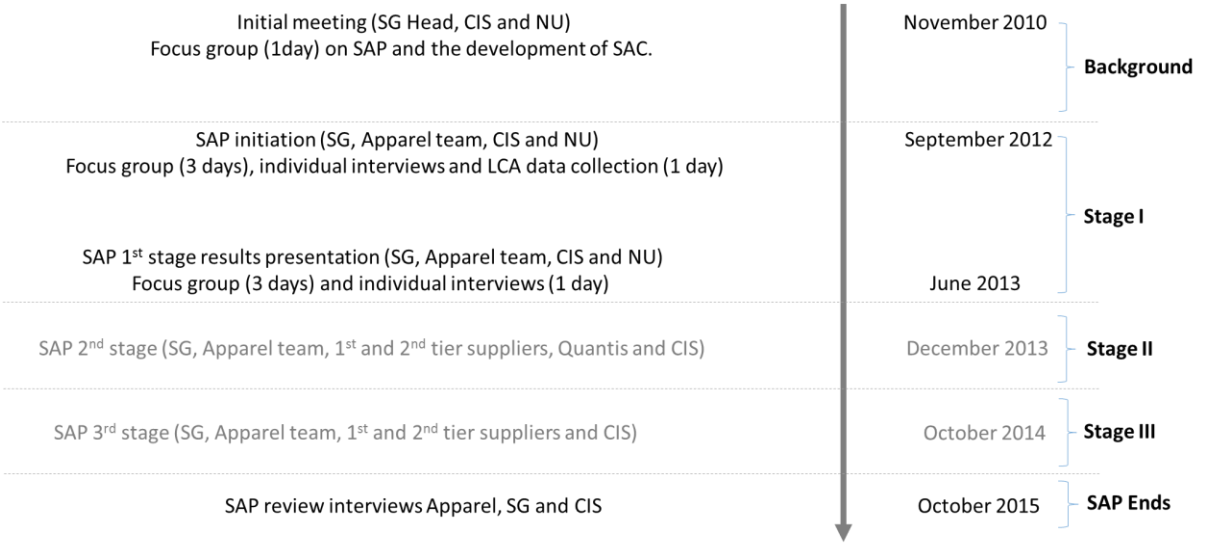


Figure 17. SAP timeline.

5.2.4. Methodological aspects

As it was earlier discussed in Chapter 3, action research influenced by engaged scholarship was the chosen method in this case. As an engaged member, the researcher solely conducted three product LCAs during Stage I and consulted Quantis in conducting another three product LCAs during Stage II. The researcher developed an apparel team process map through cognitive mapping based on focus group 1 (September 2012 at EMEA Headquarters) data collection. Based on the problems identified during the development of the LCAs and processes mapping, interventions and suggestions for the future stages were proposed and discussed during focus group 2 (June 2013 at EMEA Headquarters). Also, the researcher conducted interviews with some of the participants of Stage I two years after its end through Skype video calls).

Due to the active involvement of the researcher during Stage I, the researcher had access to the multiple sources of data, including quantitative and qualitative data collected during the LCA studies, transcripts of the two focus groups, progress phone calls (two for Stage I) and interviews (six interviews in total), cognitive maps of the value chain and organisational processes and the working and final documents of the programme.

Due to the limited involvement in the research during the next stages of the programme, limited data from Stages II and III were used, including procedural data (since the researcher contributed to their development through the suggestions during stage I), the LCA studies support for Stage II and the interviews and a focus group conducted in 2015.

5.2.5. SAP participants

In the SAP process the SG team involved the brand's employees who needed to take action on enhancing apparel business unit sustainability performance. Ten participants took part in the processes of Stage I. Their code names and their roles is described in Table 18. One of the participants was a hired contractor who helped with the implementation of the Higgs index project.

Table 18. Brand A - SAP first stage participants.

Code name	Role
D	SG Head
B	SG manager
Ro	SG manager
F	Apparel team Head
Ri	Product marketing manager
M	Product development manager
A	Product development Head
S	Sourcing manager
Ma	Sourcing manager
Gmp	Contractor project manager

The non-SG participants had limited knowledge on sustainability, and they participated in this project in order to enhance their knowledge. This is also the main reason that the most sustainability assessment and organisational processes targeted quotes are coming from the SG participants.

5.3. Data analysis

The analysis consists of four main parts. The first part focuses on the fit of LCM factors during the initial case study. The second concentrates on using the 3Ps framework in sustainability analysis practice. The third part enhances knowledge on connection (integration management) between the product and organisational processes LCs in action. The fourth part reviews the importance of the developing knowledge factor across case A.

In this section, the data obtained during the researcher's participation in SAP will be presented and analysed using the analysis lenses introduced in Chapter 4. First of all, the analysis will address the suitability of LCM factors through SAP's duration. Then, the analysis of the parts of SAP that the researcher contributed (sustainability analysis and integration management) will be further examined.

5.3.1. Filtering SAP through the lenses of LCM factors

The analysis of the SAP stages showed that there is a link between LCM factors and sustainability programme of brand A.

In this section, the researcher studies the SAP stages and analyses the flows of events using the lenses of eight LCM factors. The LCM factors analysis for this case has two dimensions and

is described in Table 19. The Table provides a data analysis index: the codes refer to the stages sequence and the specific analysis sections. However, the LCM factors sequence is not always linear.

The vertical dimension of the table uses the LCM factors (Table 14). The researcher used LCM factors as the analysis filter to evaluate sustainability-related management actions of brand A.

The horizontal dimension of Table 19 is based on the analysis of SAP stages (from Background Stage to Stage III) described in Figure 17. During the Background Stage brand A made an unsuccessful attempt to commence SAP. Stage I was the cornerstone of SAP and its results created the conditions for the follow-up stages. Stages II and III allowed to deliver the tasks based on the analysis of Stage I. The data from Stage III was based on decisions made during the previous stages. The horizontal dimension provides helpful description of the project as well as the analysis of the management actions that were directed at integrating sustainability into the company.

Table 19. SAP stages sequence.

LCM factors		Background 5.3.1.1.	Stage I 5.3.1.2.	Stage II 5.3.1.3.	Stage III 5.3.1.4.
Highlighting		√	√	√	√
Collaborationing	Inter-organisational	√	→	√	√
	Intra-organisational	√	√	√	→
Analysing		X	√	√	→
Strategizing		√	√	√	√
Decision making	SG	X	√	No data	
	Intra-collaborators	X			
Implementing		X	√		
Sustaining		X	√		
Developing knowledge (SG)		X	√		

√: existence of a factor.
X: the absence of a factor.
→: lack of change compared to the previous stage.
No data: absence of data.

Yellow area: the researcher was present - administrative stages of SAP.
Green area: main analysis of Stage I.
Blue area: the researcher had a consulting role -abstract description.

The following sections will provide description of the components of the Table 19 and explain the details of case A. Quotes of the participants will illustrate some of the data and

demonstrate links between raw interview data and case description. The sequence of components description follows the vertical direction of the table.

This way of describing a case or concept allows to fully describe LCM in contrast to existing literature that does not provide detailed case study of LCM as well as its analysis. The analysis in the literature is usually partial, it is focused on a specific aspect, and in cases when there is more than one aspect, the analysis is usually based on different cases.

5.3.1.1. Background Stage

During the Background Stage the team (including SG and CIS) was brought together to set the base for commencing SAP. However, the first attempt to conduct SAP was not successful. The Background Stage describes the catalysts for commencing SAP and the process of establishing the project.

Highlighting

The highlighting factor relates to the process of triggering action on the integration of sustainability aspects in organisational processes. An NGO initiated a campaign that started raising bad publicity highlighting the sustainability issue for the majority of apparel brands. The NGO is a societal stakeholder and its attention spans across the value chain. By informing customers in the areas where the apparel market was active, this NGO indirectly put pressure on the apparel brands. In this regard, an SG manager said:

B: 'The apparel companies were forced to take action through an organised Greenpeace campaign on chemicals mainly in the EU and the US. I think the name of it [the campaign] was 'detox' or 'detox fashion'. This pushed a lot of the industry to take the action'.

According to the info-diversity concept that was introduced by the researcher in Figure 12 of Chapter 4, the highlighting factor was initiated by an inter-organisational stakeholder that cannot be considered as a value chain actor (not VC horizontal stakeholder), but by a societal stakeholder that resides on the societal boundaries of the place layer (VC vertical stakeholder).

In the LCM cases explored in the literature, only a few authors (i.e. Regitzer, 2004) focused on cases of VC vertical stakeholders, including legislators who triggered the action. For the

first time in LCM cases literature, this case describes a new situation where an NGO has triggered the action.

Inter-organisational collaborating

The inter-organisational collaborationing factor is the process of initiating collaboration with external parties that have interest in the integration of sustainability aspects. This factor also considers the importance and variety of external relations (vertical and horizontal according to Figure 12). The action of the NGO brought attention to all apparel brands which encouraged them to work collectively (vertical inter-organisational collaboration with competitors) and to form Sustainable Apparel Coalition (SAC) to address this problem together as the capacity to work on it individually was limited. The vertical inter-organisational collaborationing was triggered by the NGO, and this collaboration was addressed by other stakeholders that are classified in the same dimension as the NGO (apparel industry). The SG manager B mentioned:

B: 'The attention raised by this campaign (Detox) brought lots of companies now to work together on that issue through SAC.'

Through the involvement of several apparel companies in SAC, brand A further raised the issue of addressing sustainability aspects at the strategic level. The SG Head mentioned:

D: 'In 2010, we participated in the initial meeting of SAC, and we realised the time to take action has come, also Higg (apparel industry product sustainability performance scoring system) was a matter of time to come.'

At that point the brand approached academia as potential collaborators for the development of their programme. As the SG Head stated:

D: '… and this was the time that I contacted you about this project because we don't have the capacity to deliver this alone.'

During the interviews the participants mentioned an importance of involving the suppliers in integrating sustainability aspects (horizontal inter-organisational collaborating) through the application of gained knowledge to enhance this collaboration. A SG manager mentioned on this:

B: 'We are not pushing them (suppliers) in certain direction with our buying power because we don't buy and sell enough for that. Maybe we can do it with knowledge and collaboration on improvement.'

The highlighting factor (mentioned above) seemed to encourage inter-organisational collaborating both within vertical and horizontal dimensions of the value chain. In the vertical dimension, two types of inter-organisational collaborating appeared, and both were anchored to the place layer of the 3Ps framework introduced in Figure 11 of Chapter 4.

- Collaboration among apparel brands. This collaboration involved actors that constituted the apparel market. These actors united their powers to solve a common problem that had an impact on the profitability of the industry. Collaboration between apparel brands was within the economic boundaries.
- Collaboration of brand A with academia. This collaboration is in the societal boundaries, the SG of brand A was in need of the knowledge of academia to develop SAP and academia was in need of real company projects to test their ideas and to expand their knowledge.

Another type of inter-organisational collaborating is on the horizontal aspect (of the VC): brand A had to collaborate on the sustainability aspects with their suppliers as brand A is not a manufacturer and the change will be implemented by other companies.

It seems that the inter-organisational collaborating spans across two dimensions that are linked to the info-diversity concept: the vertical that relates to environmental, economic and societal stakeholders, and the horizontal that relates to VC actors.

Existing literature on LCM includes cases that relate to all three types of inter-organisational collaboration [collaboration among competitors (SAC), collaboration with third parties (NGO's, academia) and collaboration with VC actors (suppliers, customers)]. Hunkeler (2004a) addresses the decision of the automotive industry to increase recycling context in their products at the industry level. Collaboration with academia was observed in the majority of cases that contained LCA studies because the companies did not have the technical capacity to deliver them. Moreover, several cases explored a collaboration with the up-stream and down-stream stakeholders. At the same time, the LCM literature does not provide an analysis of the potential dimensions of inter-organisational cooperation and this is new to the literature.

Strategising

The strategy factor relates to the provision of direction of the results to be achieved.

The SAC forced the brand's board to approve the SG proposal to introduce a project that would enhance the knowledge of the company through analysis of existing organisational processes and identification of actions that should be taken to address sustainability. For example, the SG Head mentioned:

D: 'This gave a clear message to the people at the higher level of the company that we need to explore this dimension. And gave the green light from the board to start preparing this project.'

The strategy of brand A was directed at enhancing their knowledge in order to adapt to the new demands of the market and to integrate sustainability into their processes which implies that the purpose of this LCM project is to develop sustainability-related knowledge. All the LCM cases described in the literature were directed at sustainability analysis and application of the obtained knowledge to enhance their sustainability performance [e.g. Rebitzer (2004), UNEP/SETAC (2009) and Unger et al. (2013)]. According to the data, change in external condition (SAC formation) could have influenced the way the board of brand A prioritised sustainability, however, there is limited evidence at this stage and this aspect will be further investigated later on.

Intra-organisational collaborating

The intra-organisational collaborating factor focuses on the collaboration between intra-organisational groups to enhance the sustainability performance.

The SG tried to underscore the importance of strategic decision by developing SAP for the apparel team that was in charge of the organisational processes on development of products' seasonal collections. Originally the SG aimed to initiate a collaborative project, but the circumstances did not allow it to set up the way it was planned. In this respect, the SG Head mentioned:

D: 'I tried that time (in 2010) to bring on board the apparel team here, but at that time there were other more urgent issues to solve and not time to focus. So, the project was postponed for the time that the conditions would allow it to happen that time.'

This shows that important decisions on initiation of a sustainability project depend on the priorities of various organisational groups, even if there was a strategic decision made to

move forward in this direction. Sustainability priorities often have to compete with other business priorities. Therefore, it can be concluded that collaboration factor is based on other factors such as highlight, strategy and decision-making which trigger actions that require collaboration with the sustainability group. The LCM literature describes cases of implementing LCM objectives, but at the same time the description of a failed attempt to initiate SAP is new to the LCM literature.

5.3.1.2. Stage I

This stage is the cornerstone of the SAP programme of work, and its results set the basis for the next two stages. The data collected for this stage came from corporate documents like products material bills, transcripts of the focus groups and individual interviews. Some of the interviews took place during the period of focus groups, and the rest interviews took place two years after the end of stage one and covered the decision-making, implementation, sustainment and knowledge development objectives.

Highlighting

The developments in the SAC domain changed the priority position of SAP for brand A. The time SAC launched the pilot using the Higg index (a sustainability assessment tool that provides a sustainability score for each product) with the aim to formally launch it in 2017. In addition, the NGO managed to mobilise the environmentally conscious customers. These two new triggers helped in re-enforcing the consideration of sustainability performance in brand A.

The SAC developments showed to the board and apparel team that SAP was of higher priority and therefore, it required action. The SG Head commented on that:

D: 'In the summer of 2012, SAC announced Higg index, a tool to help us (apparel brands) to develop more environmental friendly products. It seems the Higg index will go out and face the consumers and we just want to be ready. So, by the time the other brands launch their scores, we want to do it at the same time with a competitive score. To get there we need to introduce it to our processes the earliest it is possible. SAC is an external driver, it is there, close to 40% of the global textile industry is associated with SAC, it is almost a reality.'

On the other hand, customers' questions started reaching the apparel team and the SG group. The product marketing manager and a SG manager mentioned:

R: '10 years ago market did not care about sustainability, now they have started asking information. I imagine in 10 years from now they will ask many more information. – Everyone from apparel team agreed with the statement.'

Ro: 'What I see is the last two years is that we have questions on providing more information on some sustainability aspects, like safer chemicals, where products are produced, labour conditions, and show them that our information is transparent. These are coming from retailers. Probably it is something that is initiated by consumers that ask retailers and then retailers come to us. I do see an increase of questions from retailers. We receive similar questions directly from customers.'

During Stage I, the highlighting factor was triggered by:

- Vertical inter-organisational collaborators (SAC) through launch of the Higg index that all companies of the initiative should use and this put direct pressure from a collaborator and required brand A to take action.
- Customers (retailers and product users) that are horizontal inter-organisational collaborators-actors of the VC. They raised the attention of the apparel team on this issue and made the apparel team to see the need of the project.

During Stage I the highlighting trigger moved from NGO to SAC (apparel industry/competition) and the customers. These developments forced brand A to catch up. As mentioned in the description of the Background Stage, the vertical trigger started from the NGO and was addressed by SAC and in the second time (Stage I) the trigger came from SAC. This shows that the initial vertical trigger can cause other 'vertical and horizontal chain triggers' that might appear over time.

Strategising

The developments at the apparel industry level made the brand adopt a more specific strategy on sustainability and drove a more tangible project from the strategy level. The SG Head mentioned in this regard:

D: 'With Higgs coming we knew that we have to take action inside and outside the company to get a competitive score. So, we initiated this two-phase project. To understand where we stand and find the potential routes to become more sustainable.'

This allowed the senior management to ask the people below to show that sustainability aspects are integrated into the processes. A SG manager mentioned:

Ro:' From top-down there has been a pressure on sustainability to be one of our overarching goals. For example, the apparel Head is really forced to show to upper management that she takes sustainability into account in their targets.'

Also, the SG realised that they have to change their strategy in regard to their interaction with the apparel team and to help them in integration of sustainability aspects. Another SG manager mentioned:

B: 'We have to help them (the apparel team) to identify hotspots (most prominent negative impacts) and to make decisions. They don't know how to do it.'

The developments in SAC domain triggered changes of the sustainability strategy in three aspects.

- The strategy level of the organisation approved a tangible SAP with the aim to achieve a competitive Higg index score. From an explorative strategy the company switched the aim toward achieving competitive scores.
- The apparel team Head received a clear message from her senior management about the need to focus on sustainability.
- The SG realised to deliver a competitive score: they were required not only to focus on providing information, but on training (transferring knowledge) the apparel team in integrating the sustainability information into the organisational processes.

The first two aspects were focused on strategic organisational level, while the third is an example of the strategy at the organisational processes level developed by SG to enable organisational groups to deliver the sustainability strategy. The first two aspects support the tentative conclusions from the strategy section of the Background Stage (5.3.1.1.) that the strategy prioritisation is influenced by external actors and the developments described above strengthen this conclusion.

The LCM cases described in the literature address only certain strategy aspects. In all the considered cases [e.g. Finkbeiner (2004), Hunkeler (2004b), and Bligny et al. (2013)] strategies were directed at identifying risks and opportunities, while most of tangible targets in the strategic directions included sustainability analysis. Only in the case described by Hunkeler (2004a) the strategy was directed at reducing the cost of handling of an environmental aspect. None of the literature cases provided information on how the interactions at the strategy level took place. Several cases mentioned that LCM was addressed at the organisational

processes level. For example, a case described by UNEP/SETAC (2009) mentioned that LCM became a policy that everyone had to comply with. At the same time there were no references on provision of knowledge from the sustainability group to other organisational groups, except for the provision of actions taken by certain organisational groups. The researcher suspects that in that case intra-organisational training was taking place, but it was not mentioned. The cases discussed in the literature occasionally mention that training took place as part of LCM and involved upstream and downstream inter-organisational collaborators (i.e. Schmidt, 2004).

Intra-organisational collaborating

This factor covers both intra-group and intra-organisational collaboration.

The development at the strategy level (described in the previous section) as well as the customers' questions (mentioned in the highlighting section of Stage I) had an impact on the way apparel team prioritised SAP compared to two years before.

The announcement of Higg index and customers' questions attracted the attention of the apparel team (highlighting factor) and participated in the project (intra-organisational collaborating factor). As the SG Head mentioned:

D: 'These developments (Higg index launch and customers' questions) gave the push to start this project with apparel (team) on-board. Also, before it seems was not the right time to start and I see it now that the apparel is more ready for it, they want to get involved, they are more aware on the importance than two years ago.'

This development also demonstrated the need for training of apparel team's organisational groups to incorporate this information in their decision-making (intra-organisational collaborating factor). A sourcing manager mentioned the need for helping the apparel team to take action on sustainability.

Ma: 'For us that we are aware that we have to be more sustainable, we know the importance and that that it is expected internally and externally. How we start implementing into our day to day jobs? It is not clear to not SG staff. Everyone is thinking about fabrics and dyestuffs, everybody knows that is around, it is changing to be a more natural thing. But, we need to find the way to do it.'

Since the expectations of the management of apparel team regarding sustainability changed and the team struggled to meet those expectations due of lack of knowledge, the apparel

team had to change their priorities ranking and participated in SAP to obtain the knowledge they needed.

The LCM cases described in the literature did not discuss the reasons behind intra-organisational involvement in the LCM projects. Depending on the way the organisation is managed the decision leading the change can be made by different organisational actors. In the case of brand A the action was driven by the members of the apparel team, while in other cases it could be enforced by a more senior member. Usually the existing literature describes the action taken without explaining the intentions of those participating in the project that could have led to certain actions. Furthermore, this is the first time that the term intra-group collaboration is mentioned.

Analysing

The analysing factor focuses on studying current implementation and identifying risks and opportunities. In this section the researcher will discuss the thinking behind using LCA.

The SG Head set the strategy of the project, and the academic partners were invited to realise the project and to propose interventions. The plan was to use lifecycle approach to analyse the products and organisational processes and through the obtained knowledge to help in integration of sustainability aspects in the organisational processes. Below is a part of SG Head speech when he was providing directions for the sustainability analysis part of the study.

D: 'I guess what we need to define is the practical thread, the instrumental approach that we want to build, in my mind is about enabling better decisioning. That's it!! We will start from [collection's name] focusing on very particular stages/aspects of the LC and using a very clear set of tools. That we are going to apply at setting of the two stages.'

The representatives of the brand believed that results of Stage I analysis would be important for the development and implementation of the sustainability aspects of organisational processes. The SG considered LCA as a very useful tool and hoped that LCA outcomes would provide the information for product environmental assessments and identify risks and opportunities. The SG Head mentioned in this respect:

D: 'The initial analysis I hope will help us to take further steps. We will need to strategise, we need the first incremental steps, but this needs to be positioned within a broad, a more grand scale exercise. We need to find what has meaning for us, what we want to pursue. ... The way we are going to use their infrastructure (Higg index) is crucial, do we join for compliance or we

want to zoom in specific parts? What are the environmental and social values? How we frame this discussion?'

D: 'LCA provides the baseline to where we stand, it gives us the basis to set targets and develop a management plan and say this is important, it needs to be checked, that is ok, etc. It gives the basis to work towards product environmental descriptions. Provides an analysis of the environmental product characteristics are, it gives as a baseline to work with Higgs index.'

The researcher will discuss LCA analysis in more detail in section 5.3.2. For now, it can be mentioned that in almost all LCM cases identified in the literature, LCA was used as a sustainability assessment tool, but in none of the cases described the authors explained how and why the sustainability professionals were choosing LCA.

Decision-making

The decision-making factor focuses on making choices to deliver the strategy. In this section the author will discuss the managerial actions that took place during the decision-making towards enhancing/integrating sustainability in the case of brand A. During Stage I the decision-making process will be discussed in two aspects:

- the decision-making part of SAP development, and
- the integration of sustainability aspects in the decision-making processes.

Both aspects are a result of the analysis conducted during Stage I.

a. SAP development decision-making

Taking into consideration the suggestions from the analysis, for the next stages of the SAP programme the apparel team (in accordance with SG and CIS) decided to focus on integrating the sustainability aspects in organisational processes. To support this plan the project had to follow four main pylons that were presented by the SG Head and are described in Figure 18 that contains the exact slide used during his presentation. Many aspects of the first pylon were delivered during Stage I (steps 1,2,3i allowed to contribute to internal and external knowledge), the rest of the steps will be spread across Stages II and III.

Goal: Integrate sustainability into business processes to enable better decision making (to realise risk & environmental impact reduction, improved adaptability, higher quality products & processes)			
Build Internal & External Knowledge	Assess Product Sustainability (current/ future)	Sustainability Story (Brand Strategy & Design Strategy)	Define Standards for Suppliers & Increase Collaboration
1. Internal communication 2. Analysis of Apparel design & development processes (2012/13) 3. LCA of 3 representative Trail Running (SS14) items i. 2013 Design & Development focus ii. 2014 Design, Development & Manufacturing focus) 4. Analysis of Apparel sourcing & manufacturing processes (2013/14) 5. Share general learnings with suppliers	1. Higg Index i. Baseline Higgs Lite SS14 ii. Implement Higgs Lite 'live' in design & development (SS15 onwards) iii. Baseline Higgs Full (SS16) iv. Implement Higgs Full 'live' (AW onwards) 2. Implement materials library where fabrics are assessed based on multiple criteria during selection process: i. 2013: 50% ii. 2014: 74% iii. 2015: 100%	1. Define Apparel's Sustainability Story i. Needs to resonate internally ii. Market research iii. Align with business strategies e.g. marketing, hangtags etc. iv. Define performance priorities/ focus areas e.g. fabric selection, efficient use of resources v. Define long-term direction 2. Create change management plan to take ownership on basis of sustainability story	1. Establish framework for informing AHA & suppliers of standards 2. Define Standards based on Cost, Quality (including sustainability), Delivery i. Phase 1 – minimum / compliance focus ii. Phase 2 – move to best practices/ performance improvement 3. Plan basis for increased collaboration with suppliers i. Align with business innovation goals

Figure 18. SAP's four pylons to integrate sustainability into organisational processes.

Figure 18 includes SG manager B comments that brand A required:

- to build knowledge of their suppliers [inter-organisational collaboration factor of background stage (section 5.3.1.1.)],
- to develop knowledge of the apparel team [strategy factor of Stage I (section 5.3.1.2.),
- and to plan in order to enable better decision-making.

From the researcher's point of view, such sustainability programmes can be viewed as a knowledge development activity, and moreover, viewing the programme in this way can help to make it stronger.

The decisions made during the development of SAP were focused on sustainability knowledge development to enhance decision-making. The SG Head decided to expand the programme to include the manufacturing processes, to build up the relation with suppliers by sharing the obtained knowledge, to run Higg index, to develop a material library, to introduce sustainability into the organisational culture and to assign the sustainability-related roles, and to work with suppliers in order to develop the sustainability performance of brand's A supply chain. All these came after the analysis part and the discussion of the proposed interventions.

b. Integrating sustainability aspects in organisational processes decision-making

Two years after the end of Stage I, the researcher conducted video call interviews with participants of SAP Stage I, including representatives from product marketing, SG, and product development. The researcher tried to approach more interviewees from sourcing and apparel team, but it was not possible. Two of the participants were asked about the integration of sustainability aspects (environmental and social) in their decision-making, while SG person was interviewed on SG influence on this integration. Due to the limited space of this thesis, only some quotes will be mentioned.

Product marketing

Product marketing was involved only as an actor that influenced sustainability-related decision-making. According to representatives of product marketing department, after the beginning of SAP, the sustainability aspects turned to be equally important as the rest of the aspects in the decision-making. The product marketing manager talked at length about integration of sustainability after SAP Stage I, however, due to lack of space only two of his quotes are mentioned below:

R: 'I think that since we started this whole project (SAP), sustainability has as much weight as any other decision that we make.'

R: 'So you try to give it as much weight as any other important decision. Of course when challenges come it is easier to opt, it is easier sometimes to make some choices around sustainability aspect. But we take it into account as much as any other point.'

The product marketing person mentioned that sustainability is considered as an issue of equal importance in the decision-making. Nevertheless, it is important to recognise that product marketing played an influential role, and not a role where specific tangible decisions related to sustainability were made.

Product development

Product development is a function of the decision-making process: in case of the presence of a sustainability target, the latter plays an important role for product development. If not, sustainability target was considered during later stages when it was economically viable. The interviewee from product development mentioned that the integration depended on the targets set by the Head of the apparel team, as well as on approach to specific aspects and costs of more sustainable options. Below are some quotes of the product development Head:

A: 'These are two cases basically. For example, if we refer to a case where we set a target, then we know if it will be from the beginning. Why? Because we know, we need to bring recycled material. When we do the fabric selection we will always choose or try always to choose a recycled material. So in this case, you are starting from the beginning. In the cases where we don't have targets, it will not be from the beginning. It will be only in the moment that we are confronted with different scenarios that we will know which one to choose.'

A: 'I think when it is coming to the economical influence sustainability is towards the end. The first is costing and if sustainable option costs a lot we won't go for it.'

The product development Head had to make a tangible decision related to sustainability, and according to her, sustainability played equally important role only if there was a defined target and if it was not a matter of cost.

Sustainability group

SG played a supportive role and tried to create proposals based on data. The SG influenced others mainly by using LCA data. During the interview, the SG person provided examples and mentioned the relation between environmental and social aspects at product and process levels.

D: 'What we did with the product X [name of the product] was that the environmental hotspots hide coolspots, the environmental impact was around manufacturing, it was not the materials. This helps us identify where are the hidden costs. Because environmental costs imply economic costs. For example, we pay for waste of products production, same with electricity, water, etc. we pay for it. When we have this correlation between cost and environmental impact, you will be helped to improve our business profile and profit.'

The SG Head tried to adapt to the business development and sustainable development views (as described in Table 17 of Chapter 4). It seems puzzling that the person who did not have to make a tangible decision ranked sustainability the same as other business aspects, but the person who made tangible decisions on sustainability did it only under certain circumstances. Also, it is stimulating that the SG Head tried to use data and to find solutions that would satisfy both business and sustainability aspects. The interesting approach of this particular SG Head might be related to his unusual education that includes environmental management, business management and international relations.

The LCM cases described in the literature do not provide any information regarding the various decisions made by different organisational groups in regard to sustainability. The existing literature examines analysis and actions taken without describing the decision-making process. Later in section 5.3.3.2. the researcher describes the decisions made by

different organisational groups in regard to sustainability. In this section, the researcher re-interviewed the same participants to explore how sustainability aspects were integrated in their decision-making two years after the initiation of the first sustainability program in their business unit.

Implementing

The implementing factor focuses on the delivery of the decisions made.

Below the researcher will consider comments related to the implementation of sustainability actions that were undertaken as a result of Stage I. Product development and SG participants provided both positive and negative comments regarding implementation, however, due to document space constraints, the research will give a summary in the following sections.

While discussing the implementation, participants mentioned improvements as well as opportunities for improvement. At the product level, the company introduced the material library to organise the selection of sustainable materials and the selection of recyclable materials as part of the process. At the process level, the team improved marker efficiency, waste reuse and reduction.

On the problematic side, two intra-organisational and one inter-organisational collaboration issues were mentioned. A product development member mentioned that after Stage I she has not been involved in any sustainability-related process. Another member stated that there was no clear process for sustainability and the lack of the process was making integration of sustainability aspects more complex. According to the same member of team, there was another aspect that required improvement, i.e. the collaboration with the suppliers that prohibits targets achievement.

Many LCM cases in the literature provide actions taken as a result of the sustainability analysis. However, they do not mention the difficulties during implementation.

Sustaining

The sustaining factor focuses on transforming an organisational project into an organisational process.

During the follow-up interviews, participants made some comments pointing to the development of organisational processes after the initial implementation of an exploration project.

Many cases of sustainability processes sustainment were mentioned such as:

- The apparel team Head mentioned the develpment of sustainable materials library process whereas the list of the sustainable materials used in the products was continuously growing.
- A SG manager mentioned the establishment of a new role in sourcing group that worked on the reduction of waste materials.
- Another SG manager stated that LCA studies were introduced as part of SAP and now became part of a process that took place every few years.
- The product development Head mentioned a trim sustainable material target that was maintained.
- A SG manager mentioned that the social aspect assessment process used in one of the later SAP stages became an organisational process.
- The product development Head mentioned a recycled material use target for one of the products, the target was developed further and was expanded to more products.

Sustainability is linked to the organisational process development and continuous improvement, but this is not always a lean path to improvement. One of the examples given by a SG manager is provided below with the person responsible for the material library who has stopped the process.

The sustainment and development of a sustainability-related process may take time or be very fast. Depending on the effort to sustain the sustained processes can continue for a long time or stop after some time. When discussing sustainment and development, the SG Head mentioned the leadership aspect as a necessity for offering alternative solutions, instead of following the preventive principle. Moreover, while discussing the decision-making process, interviewee pointed out the leadership role the SG manager should play.

The sustainment process is not described in the LCM literature: there are some references in regard to the development of a project to an organisational process, but without any details on what helped to the projects upgrade.

Developing knowledge

The developing knowledge factor focuses on the knowledge gained from experience and its utilisation.

From researcher's point of view, the obtained information during the analysis and implementation is helpful for the continuous improvement of sustainability integration. One of the most interesting angles is the emphasis given by the apparel team to developing the state of their knowledge and learning from SAP, that was followed up by building up and continuously advancing the integration of decision-making aspects. Figure 19 is the exact slide that the apparel Head used in her presentation to explain how they expect to use the lessons learned as a result of SAP to develop their knowledge and to subsequently improve their sustainability performance.

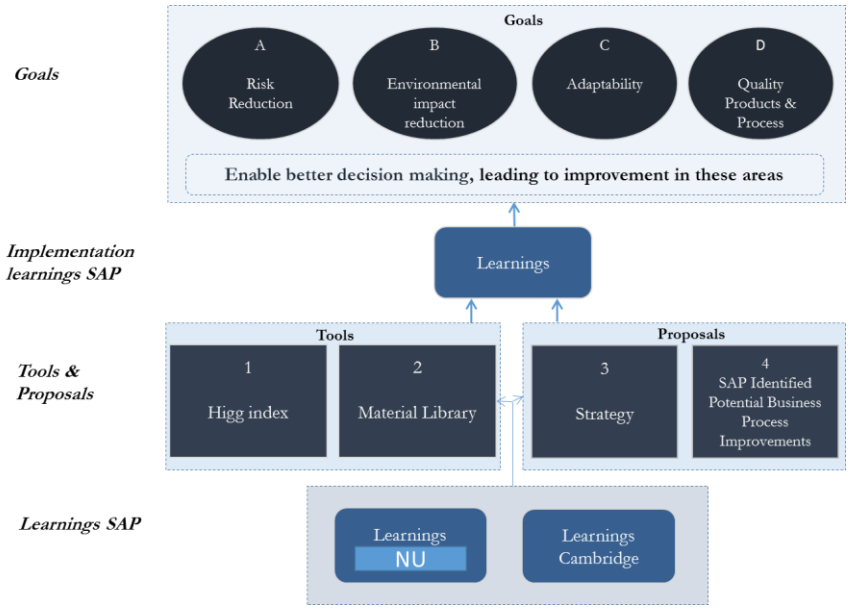


Figure 19. SAP learnings.

Building a knowledge base by acquiring more experience on sustainability issues and their integration in decision-making can potentially help to integrate sustainability aspects in the intra-organisational and inter-organisational processes. The involvement in this sustainability

project helped to develop the company's knowledge and made them aware of the areas where knowledge needs to be expanded.

Several participants stated their views on knowledge development:

Interviewee Ri (product marketing manager) stressed the involvement of individuals in sustainability projects that help to develop an understanding of sustainability perspective. However, integration and knowledge development were considered as a time-consuming process that builds up slowly.

Interviewee M (product development manager) mentioned that with the start of sustainability tasks through the process they identified more knowledge gaps. As a result, personnel involved in the project, realised that there were more to learn.

Interviewee B (SG manager) stated that knowledge developed based on information provided by the analysis. Thus, analysis helped to the development of knowledge.

Interviewee F (Apparel team Head) observed that after SAP, apparel people searched more on the sustainability aspects when they had to make a decision because they knew more as a result of SAP.

However, interviewee A (product development Head) mentioned the lack of processes of capitalising on the obtained knowledge from the Stage I. She made a suggestion that there was a need for a process of organisational learning.

Limited LCM cases discuss aspects that relate to knowledge development. For example, Holgaard et al. (2007) analysed a process of knowledge sharing on sustainability between different organisational groups.

5.3.1.3. Stage II and 5.3.1.4. Stage III

After Stage I, the researcher played a less active role in the project. Below is a short description of the rest SAP steps.

Analysing and decision-making of Stage I had a significant impact on Stages II and III. The introduction of the social aspect in Higgs index by SAC attracted the attention of brand A as there was the intention to conduct a SLCA. When SAC initiated the social Higg index

development, the company approached the researcher to conduct the SLCA as part of Stage III analysis, but the author could not work on this project due to other commitments.

On the inter-organisational collaborating factor for the next two stages, the company established a research project with one first-tier supplier and two second-tier suppliers. A collaboration was established with LCA consultants to conduct follow-up LCAs. Moreover, during Stage III another university joined the project to lead the exploration of social aspects.

During both stages the strategic decisions (addressed in Figure 18) led the project. During Stage II the team decided to explore the social aspects at the Stage III.

In regard to the intra-organisational collaboration, the SG team established collaboration with sourcing group.

As to the analysing factor, the second stream of LCAs were conducted as well as more Higgs index exercises on top of material assessment with suppliers.

5.3.2. Sustainability analysis objective

The adoption of the 3Ps framework helped to make a direct connection between the impact sources and potential solutions. In addition, it helped to assess tools strength and weaknesses.

The sustainability analysis objective refers to the assessment of a certain situation and identifies risks and opportunities.

The sustainability assessments conducted during Stage I included LCAs and the use of Higg index. Three LCA studies were delivered by the researcher. These LCA studies were also externally assessed and approved for their quality by LCA consultants. Then, an analysis of Higg index tool (provided by SAC) and its comparison with LCA was conducted in order to identify the strong and weak points of Higg index in information provision.

5.3.2.1. Conducted LCAs

The LCA studies were conducted in three steps: the LCA focus, the data collection and the models development. These three steps are described in the following sections.

LCAs focus

The sustainability analysis part of SAP requires the identification of the focus of the study. The SG team asked the apparel team to propose three typical apparel items (one t-shirt, one trouser and one jacket) of the last season to use them as objects of the LCA study and the researcher conducted the LCA analysis. The descriptions below will mostly focus on one item, as there were similar issues in all apparel items.

LCAs 3Ps data collection

The design of the LCA data collection process was influenced by the product-process-place (3Ps) layers introduced by the researcher in Figure 11 of Chapter 4. The 3Ps framework helps to assess data reliability and integrity, and to understand which aspects of the LCAs results can be trusted.

To initiate the data collection a knowledgeable person from the product development team was assigned to help the researcher to identify the data required for the LCA. That person provided the bill of materials (BOM) for three products, that contained all the information that apparel team used for the manufacturing of the products.

Following the 3Ps layers' logic the researcher created a schematic record representing different sources of information (Table 20). The information was classified for each material according to the product-process-place layers as described in Chapter 4.

Table 20. T-shirt product-manufacturing process-place information collected.

	Found in material bill		Underscore what was included in the LCA				
	Informed by Product development member		:(assumed other location				
	Found in costing sheet						
	No info in material bill had to ask supplier						
	No info in material bill had to ask supplier, but no answer						
	Pass request, but supplier was not contacted (time constraint)						
	Did not ask						
	Info from literature, practitioners						
	Actuall use measurement on product						
3Ps analysis	**Product part**			**Process**			**Place**
Category	**Product part**	**Content - Materials**	**Part use to assembly the product**	**Process tree (process names only)**		**Supplier**	
Fabrics	Fabric A	52% PET (assumed 100% PET) 48% Cocona	Fabric use before the cutting stage 102.9 gr	Process tree	Cocona process	New wide	Taiwan :(
	Fabric B	85% PET 15% Elasthane	Fabric use before the cutting stage 44.6 gr	Process tree	Elasthane different processes	Texcare	Taiwan :(
	Fabric C	80% PET 20% Elasthane	Fabric use before the cutting stage 22.7 gr	Process tree	Elasthane different processes	H-ONETEX	Korea :(
	Fabric Ref	80% Polyamide 20% Elasthane glass bead bonding (PU resin) Okotex Cl 1 certified, NO PVC pr PTFE	Measured use on product: 1.4 gr Fabric use before the cutting stage 2.4 gr 340 gr/m2, 0.01 yard (can calculate use because we know the area)	Fabric that has a resin on top	 Elasthane different processes	Regina elastic	China
	2025 (collar, chinguard)	100% PET	Consumption: 0.08m, width: 1 m, **need weight per m2 to calculate the use**			Duta Interlining	
Embroidery	Embroidery (eyelet)	100% PET	Use in the sewing (eyelet included) 400m		Similar to fabrics	Kemilau	
Yarn	Yarn 0004	100% PET			Similar to fabrics	Lee-Lin Apparel Co. Ltd	Thailand
Necktape	T PS5205	54.15% Nylon filament ≈ Polyamide 42.08% Elasthan 3.78% Elasthan Yarn	1 piece, width: 10 mm consumption: 0.5 m measured use: 0.3 m/ 0.8gr		Similar to fabrics	Pro stretch	China
Elastic binding	T PS5136/A/1	61.32% Nylon filament ≈ Polyamide 34.65% Elasthan 4.03% Elasthan Yarn	1 piece, width: 20 mm consumption: 0.75 m measured use: 0.58 m/ 3 gr		Similar to fabrics	Pro stretch	China
Zip	Z ASICS NYG. (puller)	TPE (Thermoplastic elastomer)	Piece: 1 & width: 0.2 gr		Moulding	YKK	Indonesia
		Zamac (Zinc alloy)	4mm 1.2 gr		cations/SSNPR%2		
	Z NYGUARD (teeth)	100% Polyester 6,6	width: 6mm 18 cm 0.7 gr, 18 cm		Moulding	2A- NYGUARD	China
	Z NYGUARD ZIP (tape)	100% Polyester	size: 4mm 1.4 gr, 21.6 cm		Similar to fabrics	2A- NYGUARD	China
	Z NYGUARD ZIP (yarn for stitch)	100% Polyester	0.1 gr		Similar to yarns	2A- NYGUARD	China
Seams	M BONDED SEAMS	Ester Polyurethane	width: 10mm **consumption: 0.30 m ?**		?	Bemis	
Care label	L0004	100% Polyester	1 piece, 35*30 mm ? 1 gr		Similar to fabrics	???	???
Prints	PG 0001 (Logo)	Water-based ink Reflective elements Coupling agent	1 piece, 7 sqm		**Printing? I know the process**	A-TEX	China
	PG 003884 (logo inside)	Aluminum powder	1 piece		**Printing? I know the process**	A-TEX	China
	P AHK1109-0136 (Fuji logo)	57% Polyethyleneterephtalate 27% Ti-Ba glass beads 11% Polyethylene 4% Acrylic resin 1% Polyurethane resin	1 piece, 2 cm		**Printing? I know the process**	KWANTAT	China
	P TRAIL 008&9	Silicon rubber	2 pieces		Heat setting	Simut	
Hangtag	HC AS-BK1 (Corporate booklet)	White coated paper Solvent based ink	1 piece, 60*230 mm 300 gr/m^2, 0.02gr/pc			A-TEX	China
	HH AS-HTB4 (Reflective)	White coated paper Solvent based ink	1 piece, 114*60 mm 250 gr/m^2, 0.01gr/pc			A-TEX	China
	H IQ SEEN	Recycled paper with lamination on both sides	1 piece 250 gr/m^2			Regina Elastic	China
	H COCONA	Recycled paper	1 piece 1.2 gr			New wide	Taiwan
Packaging							

The analysis of Table 20 demonstrated the need for separation between 3Ps layers of the VC. For the LCA studies, a part of the product and processes were considered while the place data were not related to actual production locations. The section below provides further analysis of the data collected on each of the 3Ps VC layers and discusses efficiencies identified as a result of 3Ps approach.

a. Product layer

The product layer connects the manufacturing process layer and the place layer across the VC. It focuses on the type of material used and its development from raw materials to product parts, then to product and waste. This information follows the product's lifecycle and therefore can help in identifying two types of improvements:

- to identify product raw materials or parts that could be replaced with more sustainability friendly materials;
- to identify inefficiencies across the VC that can be linked to inefficiencies on material/processes/place.

As to the material sustainability aspect improvement, brand A did not introduce a process of assessing the sustainability performance of the materials. However, they had a material library with all the technical information about the materials, but not considering sustainability aspects. The lack of a material sustainability library triggered the CIS team to propose this first intervention (i.e. the development of a material sustainability library) for the product development to be able to consider the sustainability performance along with the technical performance of the material.

At this stage of information collection, the product development person was able to provide through the BOM the raw materials types of most of the fabrics and the rest product parts raw materials were identified through various routes mentioned in Table 20.

Later on during the project after running a pilot of the material library, the member of the product development staff mentioned:

M: 'I would like to use this process as a material library already, it will help us to make a decision a lot. We have an excel sheet with the materials we have assessed lately on a particular season. We can work on it and make this library.'

Gmc: 'The key success factor for me is something like a materials fabric library; it is quite important to have a good base to build on.'

This new organisational process (a new way of managing the material library) was aimed to support the decision-making at the product layer (Figure 20). The CIS team also proposed a material rating system as well as a strategy to use materials of preferred performance and to maintain space for creativity. Nevertheless, at this stage of the VC the material is considered

as part of the product layer. However, it carries the process and place layers that contribute to the materials (product) assessment.

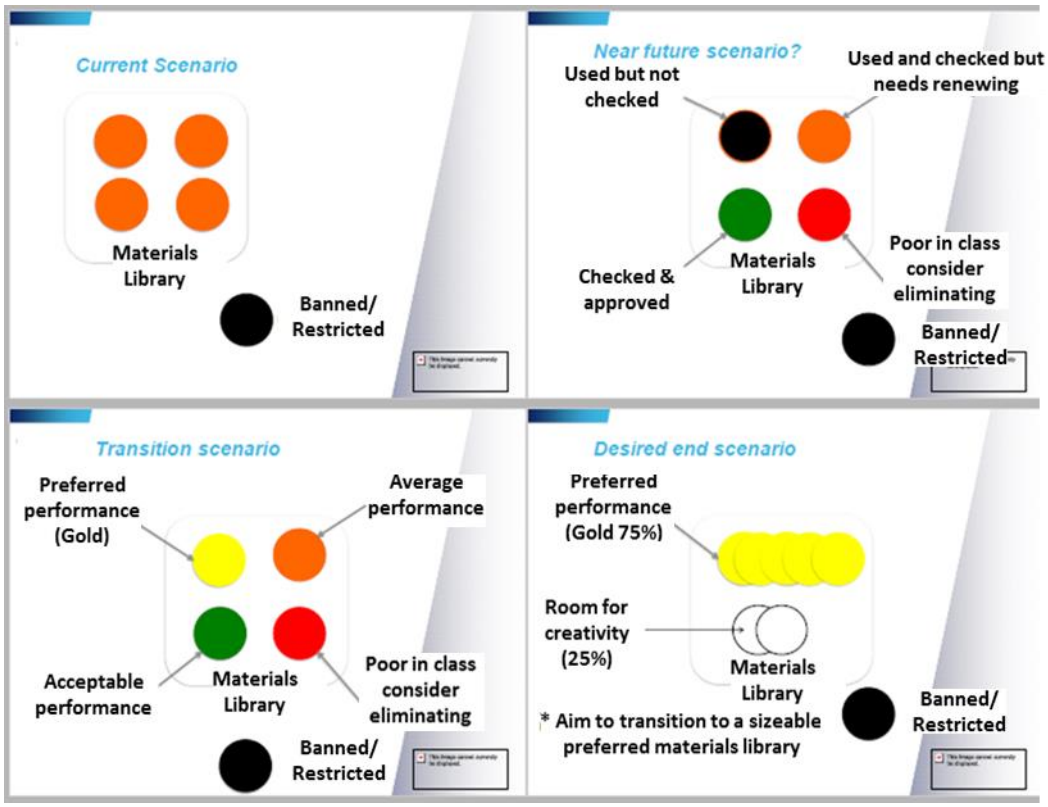


Figure 20. Prototype of material library.

The information regarding product material content across the VC stages was very limited. The product had five product stages across the VC: the raw materials, the product parts, the assembled product the use phase (washing) and end-of-life (waste). The researcher started from the assembled product level (as the product developer aimed to develop the final product) and then worked backwards in the VC to find the rest of the information.

During the analysis of the BOM documents the researcher realised that the development team was not aware of the products material weight breakdown, despite the fact that amount of fabric used for the cutting process is at the product parts of VC. The product development manager mentioned:

M: 'I do not know the weight of the product; we do not weight them to be honest. We calculate how much fabric is used to make the t-shirt not how much is on the t-shirt.'

It is very interesting that the product developers did not know about the content of the final product. This can be explained by the differences between business and sustainability philosophy since these groups focus on various aspects of the same VC point. For example,

product development focused on making the product while SG paid more attention to the contents of the product.

Unfortunately, the team was not able to identify a person who could have provided information on the amount of the material that ended up in the final product, so the researcher addressed this question to the suppliers through the product development manager. The suppliers did not have a direct answer either, but they provided the marker efficiency and this allowed to calculate the material on the final product.

Marker efficiency (calculation is described in Figure 21) is the material efficiency of each fabric during the fabric cutting process. The cutting process refers to the cut of the fabric board (a perpendicular fabric shape) in the shapes of fabric that is used in the product. The rest parts of the fabric board are considered as waste. The marker efficiency of the product is described in Table 21.

Table 21. Fabric sheets marker efficiencies.

Garment	Fabric	Marker efficiency (ME)
T-shirt	A1	73 %
	B1	68.4* %
	C1	75.1 %

*ME calculated as an arithmetic mean of two separate sheets at 60.9 % and 75.8%.

At this early stage, it was realised that the brand needs to develop an information database that would contain specific information for each material used. The only information identified was the product parts content (fabric board), and the assembled product content (fabric shapes used in the product) could be identified by using the information of the marker efficiency process. As the information across the VC was not available, the researcher had to work at the processes layer to consider the efficiency of the stage fabric cutting (marker efficiency) and to identify the product materials used across the various stages of the value chain.

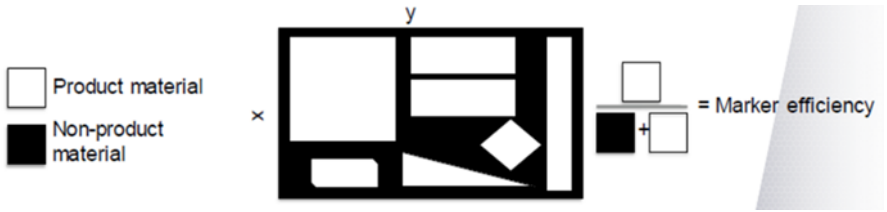


Figure 21. Marker efficiency calculation.

The product development person was not able to identify another person at the company who had information regarding the manufacturing processes tree (sequence of manufacturing processes from raw material to product), or a document that described them. The researcher developed a questionnaire on fabrics production process tree, and the survey included questions on the types of the processes while leaving out more detailed data as per suggestion of the development person who mentioned that otherwise, the reply rate would be very low. Only the manufacturers of the main fabrics submitted the filled questionnaires. For each of the parts of the fabric the researcher conducted a literature research to identify the typical production process. The knowledge of the production processes tree and the process efficiency allowed to estimate the granulate use and the use of fabric on the product.

Table 22 describes the calculations made by the researcher to identify the material content across the product VC stages. The analysis showed that at the material level the production of the T-shirt's fabrics required 174 gr of granulate while only 121 gr made it to the final product. Around 30% of the material used did not end up in the final product, and when the use of the actual weight described below was inserted in the calculation, the share of wasted material increased to 39%. This finding showed that across the value chain stages there were process inefficiencies and that would be explored in the processes level analysis.

Table 22. Material weights at each stage of the process.

Garment	Fabric	Material	Granulate	Costing sheet – Fabric		ME	Calculated use
T-shirt	A1	100 % Polyester	106	103	Scouring	73 %	73
	B2	85 % Polyester	37.9	44.6		68.4 %	30.5
		15 % Elastane	6.6				
	C3	80 % Polyester	18.2	22.7		75.1 %	17
		20 % Elastane	4.5				
	Total		174	170		-	121

As to product layer, it is important to be able to make material comparisons and the material use across the VC to find areas for improvement and prioritise actions as one action could have a greater impact than another. For example, in Table 22 shows that marker efficiency provides more potential for improvement (170-121=49gr) compared to the fabric production (174-170=4gr).

b. Processes layer

At the manufacturing process layer, the information was very limited. The following comment of a development person on processes knowledge could be considered as a typical answer.

M: 'On the raw material processes, I do not know how precisely they make polyester. Coconut fabric… I am not sure, I believe they take out the carbon from coconut. About the fabric creation processes, we have an idea, but I do not know for sure because each fabric is unique. We give the specifications that each fabric need to have and the material suppliers figure out the processes that need to take place.'

The researcher had limited information regarding production processes, however, he decided to work on the process stages that he could obtain tangible data from the VC. These processes stages were the fabric use before cutting, the cutting process (marker efficiency) and the final product. The researcher decided to start from the most tangible stage that was the final product which the apparel team made it available for the researcher.

To make sure that the numbers are right the researcher measured the actual weight of the T-shirt. The estimated 121 gr were very close to the 125 gr of the actual weight of the T-shirt, but the estimation did not include the trims that were in the actual product. To estimate the difference between actual and estimated use the researcher disassembled the T-shirt and measured the weight of the panels. The comparison is described in Table 23.

Table 23. The difference between 'Marker efficiency' (ME) method of calculating the weight of panels and the 'directly measured' (DM) method.

Measurement	ME (gr)	DM (gr)
Fabrics A1 and B2	103.5	94.4
Fabric C3	17	14.1
Fabric weight	**120.5**	**108.5**
Actual garment weight	**125.2**	**125.2**
[Actual weight] – [$\Sigma_{A1, B2, B3}$]	**4.7**	**16.7**
% of garment not accounted for by fabric panels A1, B2, B3.	**3.8 %**	**13.3 %**

The estimation shows (108.5/120.5) 9% higher use of material compared to reality. This result shows that the marker efficiency calculation has an error. Moreover, this shows that there might be a potential for greater marker efficiency.

When a development person was asked on the source of the error, she mentioned two different factors.

M: 'Yes, this happens, it can be around 10-15% dissimilarity. It can happen because of the price negotiation. The supplier says that needs a larger panel when it is not true. Or the estimation of the designers on the size of the parts is not right and less fabric is needed.'

This finding indicates that the fabric use estimation process needs to be more reliable because the product specification appeared to be 10-15% higher than reality and this has an impact on the calculation of the environmental performance.

The error of the estimation is described in Figure 22 with red colour. The fabric panel before the cut had two dimensions (x and y), the parts to be cut (product material) are described with white color and the non-product part of the panel with black. According to the product development manager, the supplier had increased the x dimension of the fabric role (red color) and more fabric was used to cut the same amount of product material. This constitutes that the marker efficiency can be improved in paper (in the case of false data) and or in action (in the case of right data).

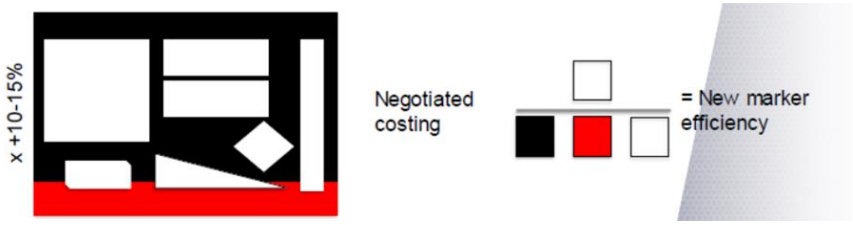


Figure 22. Schematic of marker efficiency calculation that includes the found error.

This inefficiency triggered further analysis of marker efficiency achieved through this production process. The analysis of the marker efficiency range of the fabrics used for this season is described in Figure 23. The range spans from 50% to 87% with a mean on 75% and the efficiency varies by garment and supplier.

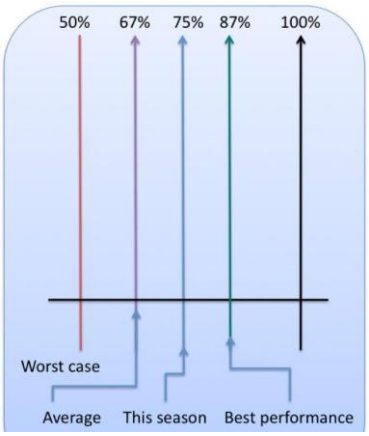


Figure 23. Marker efficiency range of the fabrics used for season X.

This inefficiency also underlined the proposed intervention related to the process layer, that looked at the marker efficiency and the identification of the optimum marker efficiency rate, track and benchmark performance over time while driving performance improvement. Brand A responded to this intervention by hiring specialised consultants on marker efficiency. The consultancy helped them in improving their marker efficiency through time.

Regarding the process layer, it is very important to find ways to improve input/output rate of each process stage by having the more output with less or same input and not greater emissions. In case A process improvement comes with process changes across the VC, the change should be assessed with a process layer perspective across the VC stages.

c. Place layer

At the Place layer, the production processes of three garments take place in five countries (i.e. Taiwan, South Korea, China, Indonesia, and Thailand). The information on the electricity mix of each country was obtained from the International Energy Agency (EIA). Due to the software dependency the researcher had to purchase the databases of each country, but this was not economically feasible, and the free option of the German energy mix was utilised. As described in Table 24 the electricity mix in Germany is very different, and this will have an impact on the results of the LCA. On the other hand, when the focus is on the processes the same location context can contribute to more accurate production process comparisons. At the same time the LCA results will not be accurate at the place level. This points to the use of the same location if we want to make a comparison at the process layer, but if it is important to compare product layer comparisons we need the actual locations.

Table 24. Electricity mix comparison between the place considered in LCA calculations (Germany) and two of the actual places (IEA, 2012).

		Germany	Taiwan	Indonesia
Fossil	Hard coal	21%	53%	
	Natural gas	7%	26%	17%
	Heavy fuel oil			29%
	Lignite	26%		41%
Nuclear		17%	17%	
Renewable	Biomass	10%	1%	
	Hydro	3%	2%	8%
	Photovoltaic	6%		
	Wind	10%	1%	6%

LCAs models development – decisions based on available information.

Due to lack of information, which is described in Table 20 the researcher along with the SG decided to focus the LCA only on the fabrics for which the information was available. According to Table 23, this decision the t-shirt LCA considers (100-13.3) 86.7% of the product's material.

The data obtained for the LCAs allowed to develop the models described in Figure 24. As it was explained earlier, the LCAs included only the main fabrics.

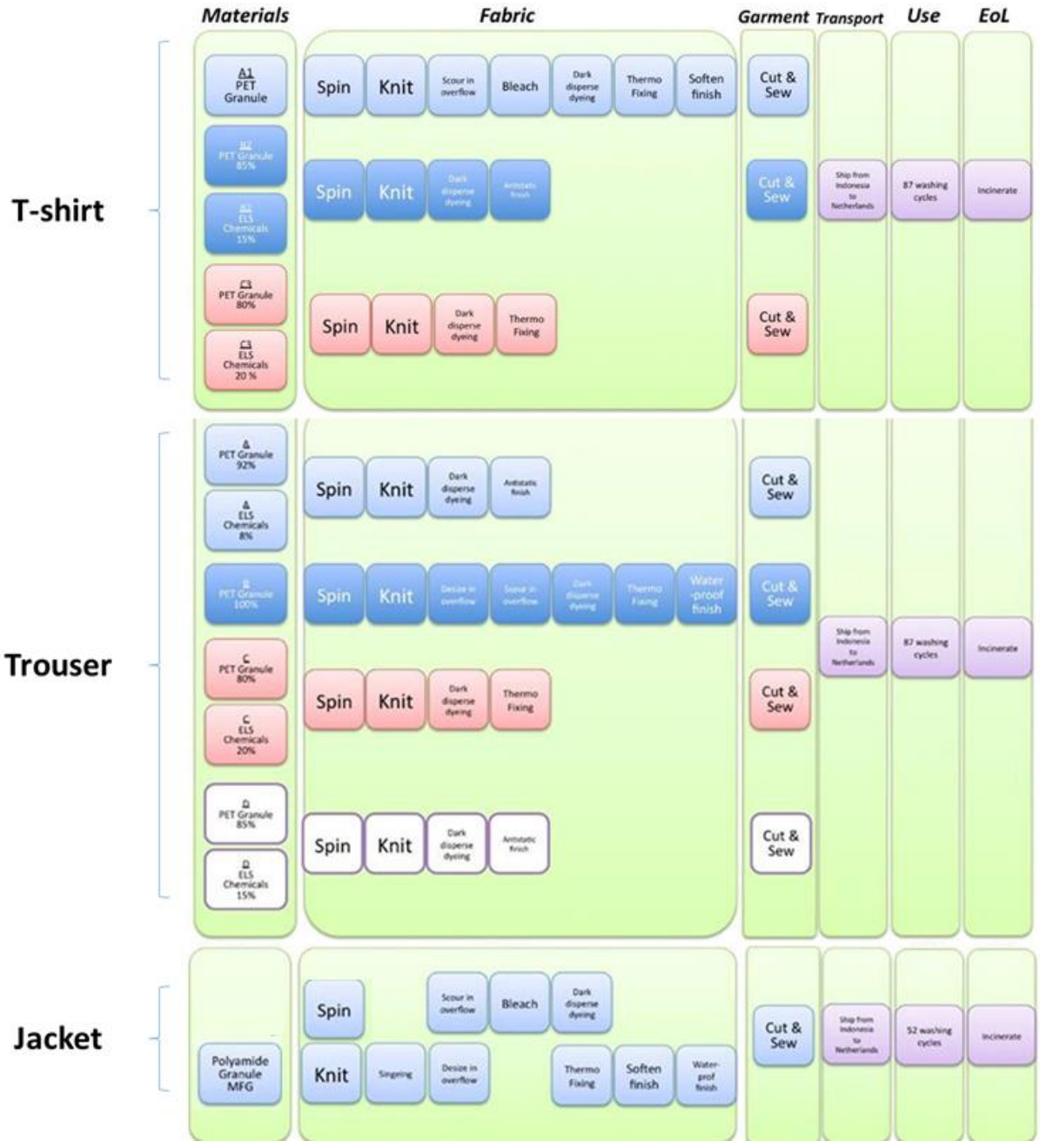


Figure 24. Summary of lifecycle models.

All three models were tested using Gabi 4 LCA software, and Figure 25 describes a part of the model of the jacket (fabric formation) that was the least complicated as the product was made of only one type of fabric.

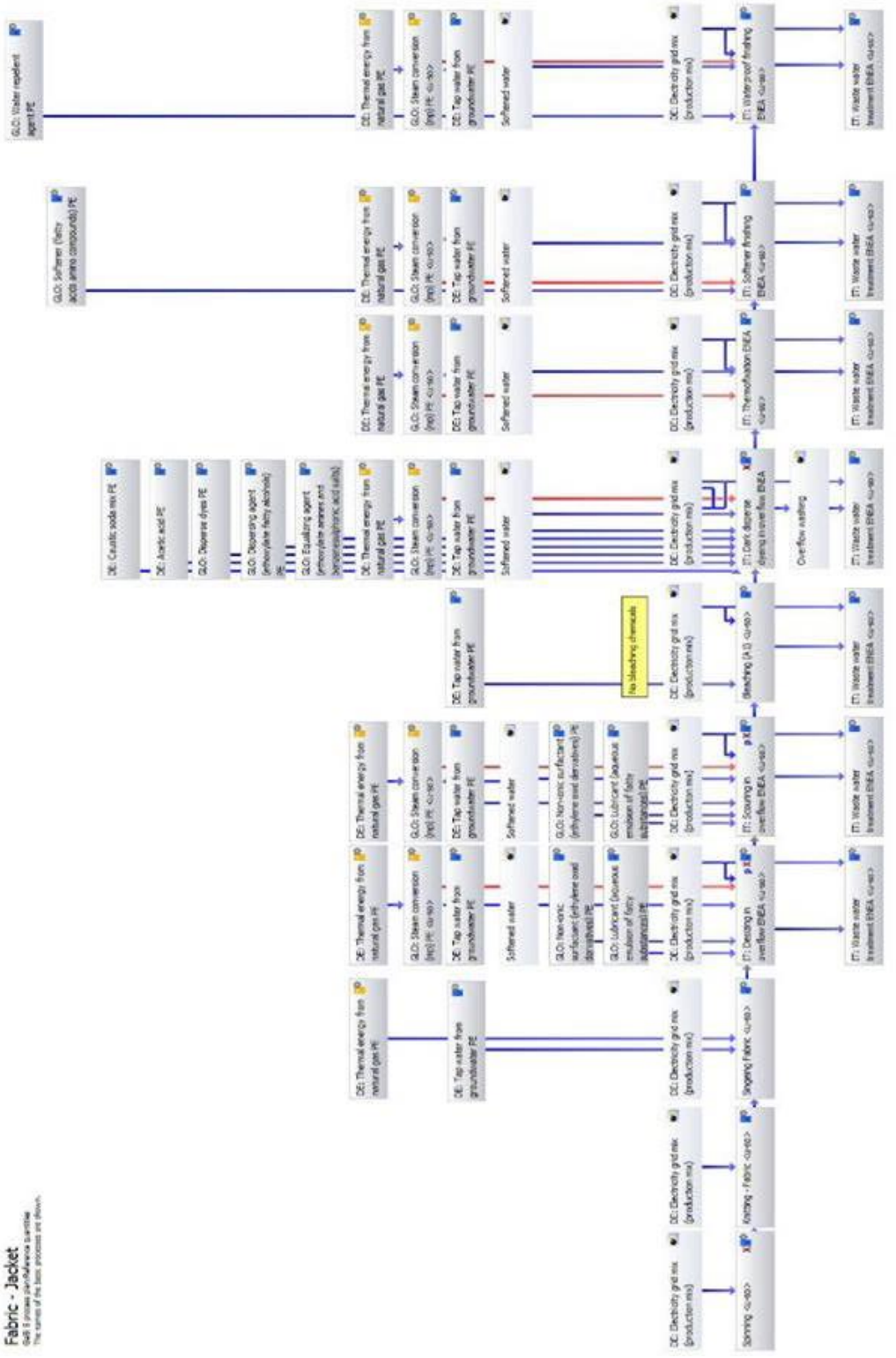


Figure 25. LCA input-output model for the fabric formation stage of Jacket – from granulate to fabric.

Conducted LCA summary

This was the first LCA ever conducted by the apparel business unit of brand A. The information sources were limited, and the quality of information was controversial. The researcher used the 3Ps layers approach to develop a data infrastructure and to conduct LCAs where the user of the information would know which part of the information were reliable in contrast to the ones that required further exploration. The LCA guided the focus of Stages II and III to a large extent. Moreover, the 3Ps approach helped the researcher and the rest of the academic teams to identify interventions that helped brand A in enhancing the sustainability performance of their products.

The situation with information accuracy has not been described before in the LCA literature. The business people value more cost aspects of used materials and not the material quantity as the sustainability people do. These different points of view can contribute to inaccuracy of data because business people who recorded them had very different viewpoint.

The researcher shared a template of an information infrastructure for PLM system based on the 3Ps approach that allowed to identify the hotspots of different products along the VC with the SG Head. The latter proposed to adopt this approach, but the CIS team postponed the plan because of lack of time.

5.3.2.2. Results presentation format - LCA versus Higgs index

This section is focused on the discussion of sustainability assessments results presented during the second focus group of Stage I. It points to the LCAs results presentation and the analysis and use of Higg index exercise on an apparel's collection.

The LCA results are impacts expressed in a quantitative form that mainly aim to inform environmental experts on the environmental impacts of the model as described in Figure 26.

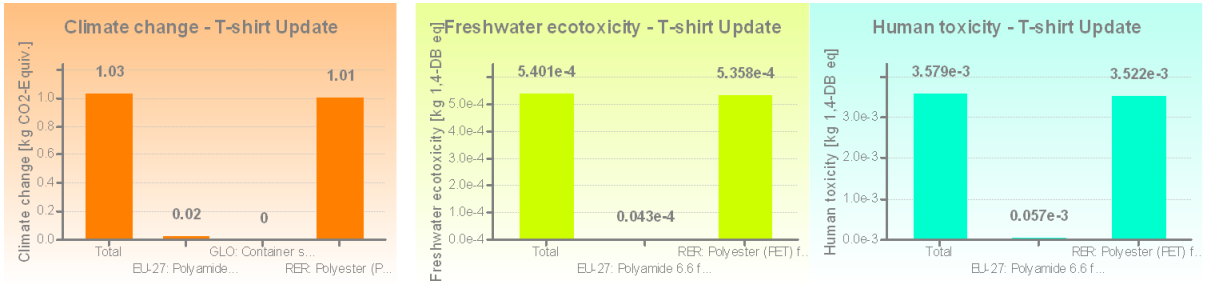


Figure 26. Gabi T-shirt impact categories results.

It is important to present the results in a way that will also inform or focus the attention on the decisions and areas that can influence the environmental performance. An example of this approach is presented in Figure 27 where the same results as in Figure 26 are aggregated to focus the attention on the lifecycle phase with the highest impact.

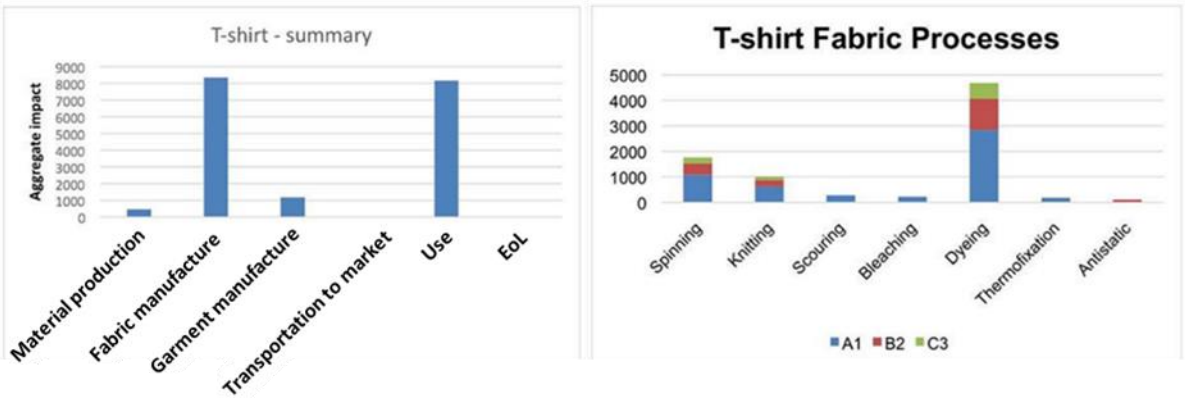


Figure 27. Gabi aggregated impacts results.

The LCA results presentation described in Figure 26 provides a holistic VC view and it corresponds to the outlook of a sustainability professional. This presentation of LCA results is aimed at informing about performance and identifying the sources and types of impact. On the other hand, the presentation of LCA results (Figure 27) include VC chain actor approach that is important for a professional who needs to weight different impacts and their sources in order to make decisions that will provide a boost to the sustainability performance. This type of analysis provides an individual sustainability pillar result aggregation, and the 3Ps layers analysis approach can guide the user and show what results are more or less reliable. This does not consider the place approach, and so it can be used only when process focused analysis takes place.

The researcher asked the SG Head about his opinion on these two different ways of communicating sustainability performance information that can be helpful to strategise the focus of the corporate sustainability efforts and to make specific decisions. He mentioned:

D: 'This is not the first time we order an LCA study at the company level, it is the second. We had a collaboration with another university on a project for X [name of another business unit]. It was a two years' project, the result was a highly technical and quantitative report that actually we could not touch for long time because we could not understand it. We did not have the knowledge and experience on how to use this information. We learned a lot about the production process, but the environmental results could not help us to take it further. That is why we contacted you [Cambridge] because you have a different approach. You focus on the managerial part on how this information will be used by the company to inform our decisions. And this is apparent with your LCA report that was aimed on the aggregation of the impact in ways that will say something to us, not a highly quantitative environmental impact result that I don't know how this is translated in our processes.'

Another way of presenting the results is by using ranking. This approach provides a picture of the impacts ranking and the parts of the lifecycle where impact appears. For example, the SG manager mentioned:

B: 'I want the results to tell a story to me. I am an environmental engineer I can understand the quantitative impacts, but the apparel people cannot because their background is not the same. We [SG] can use the environmental performance bar charts in our sustainability report or a product declaration, but if we want to improve things we need to present the results in a way that the results are transparent to apparel that will have to consider this info in their processes. I believe that the aggregated impact and the impact ranks are a transparent way of passing the results. I would keep the quantitative results for SG or a meeting where the focus would be on the scientific side not business processes.'

According to the comments above, it is difficult to make a link with the business aspect using the technical approach of Figure 26 as it is designed for sustainability audience and it is not very helpful in engaging the business audience because after stating the problem they need a solution that fits with the business. At the same time aggregated results help in creating connections between the technical sustainability part and the business aggregated part and give an opportunity to move back and forth whenever needed.

Higgs index

Higg index consists of a dashboard with certain options that are focused on apparel product design and manufacturing processes. The use of Higg index does not require any information on the manufacturing processes or place level because the calculations are based on pre-set options that are not available to the user. At the product level, only the amount and type of materials used were requested and the rest product/material layer related factors are common (have fixed value). The user chooses the options corresponding to the product/facility profile (product and process levels) and inserts the quantitative data, and the index provides a score from 0 to 100 (the higher is the score, the better is performance). The place level is not addressed by Higgs index, as it does not consider the different conditions in different locations. Figure 28 provides a presentation of information in Higgs index, Figure 28 gives a score for each product and the score breakdown according to the use of different materials (product level) and different manufacturing processes (processes level). It should be noted that Higgs index v.1 did not consider the down-stream VC part. Higgs index v.1 is mainly focused on the product layer, and this makes it a useful tool for designers, but not for product developers. In brand A, the designers did not consider sustainability while product developers could have been involved. This shows that Higgs index aimed to influence the product level while brand A product development had more influence in processes layer.

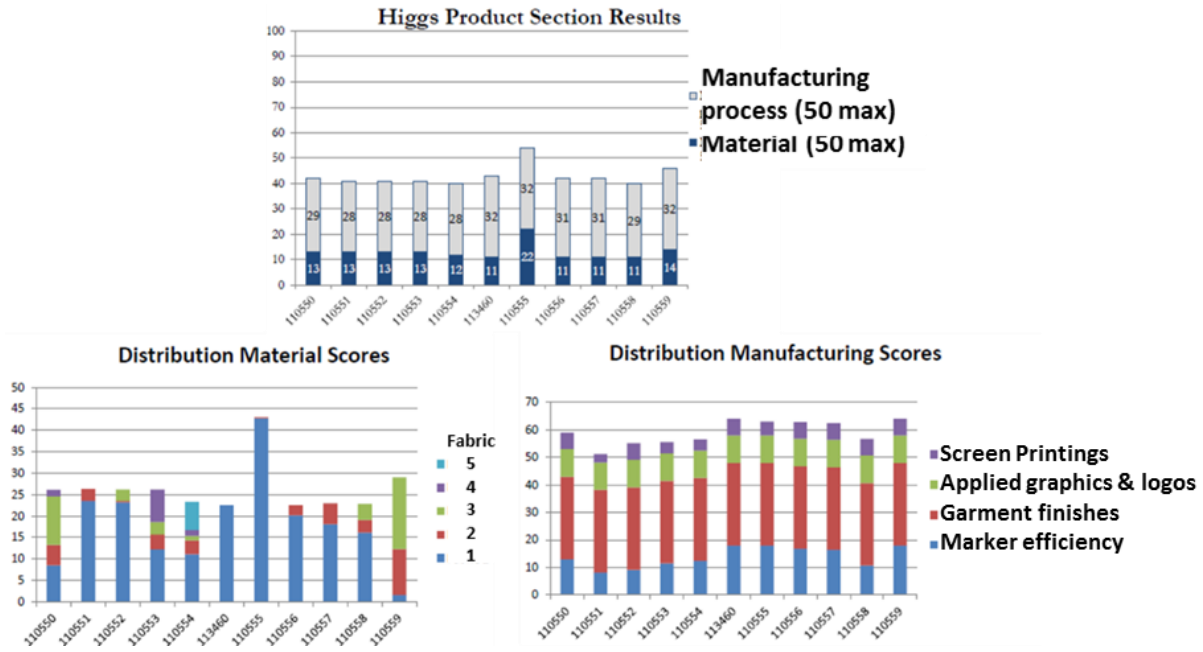


Figure 28. Apparel collection Higgs index v.1 results.

Interviewees from different organisational groups mentioned the importance of knowing the information presentation preference of the receiver when the sustainability manager informs his decision.

According to a SG manager, each organisational group has different information needs in Higgs index, and this means that certain groups will be in favour of Higgs and some not.

Ro: 'In SG, when we have to make decisions we like to have the numbers and follow up with a brainstorming, for other these must be very heavy. If you have four different figures per department the importance of each figure can be different. We cannot make all our decisions based on ratings. Both ways are useful: the single scoring (of Higg index) or the complete analysis (LCA) depending on the different departments information needs.'

Ro: 'It is difficult to judge Higg [index] precisely; certain things are more difficult or need to move or other factor has to be moved or added. Certain categories are more important for SG than others. Also parts of the organisation put different emphasis/weight on different parts or on environmental versus social aspects.'

The apparel team manager mentioned that product marketing that was not involved in the technical details and was more interested in finding a clear way of communicating environmental performance, was in favour of Higgs.

F: 'This kind of thinking will help product marketing in particular, because the environmental impact numbers can go to sustainability report and the Higg score [can] show our improvement from previous collection or compare our products with other brands.'

At the same time during the discussion other participants expressed their doubts regarding importance of Higg results to contribute to informed decision-making process. The SG Head and a SG manager stressed that Higgs is just a tool that provides a score and does not provide direction on how to improve, and therefore, Higg should not be used as a tool that the sustainability strategy should be based on.

D: 'The problem with Higg is that it is a lagging indicators set. It gives an idea on what you are doing, but it does not provide any guidance and this is how we have to perceive and position it. It does not help in decision-making. Hopefully that will come from the tools we are developing here. It is important for people that need guidance to know that it won't come from Higg. People look at Higg and think 'If I will do what it says everything will be fine.' To get a score is a premise. It is built like a lagging indicator set, not a leading one. The leading indicators is a very challenging concept.'

B: 'This index won't help us with the details.'

It was interesting that except for the SG members, members of the apparel team, including the product development manager, mentioned the weaknesses of the tool to inform

decisions. For example, it was said that Higgs provides just a score and does not provide direction on how to improve performance. Therefore, according to some participants, Higgs should not be used as a tool that the sustainability strategy should be based on.

M: 'You cannot tell that recycled polyester is definitely more sustainable as you do not know their processes or from where they ship the materials to recycle them and then at production again. When LCA can give this answer I guess. With Higg I get this score. Is it a good score? I do not understand what this score means. When we have two different [scores] to compare, it is fine.'

The variability of options of Higgs has another layer that is linked to the difference between philosophical approaches exercised by business and SG: sustainability focuses on how to improve the process and decision-making, while business usually sees Higgs as another project altogether.

At the first day of the second focus group, the apparel team provided an input based on their experience of the first focus group by using the Higg exercise. Figure 29 contains the exact slide that was used during the presentation. This slide presents information on how a team that is not focused on sustainability, and is forced to integrate sustainability aspects in decision-making, sees the integration of Higgs in their processes.

The researcher analysed Figure 29 using the lenses of Table 17 in Chapter 4 that describes the differences between sustainable development and business development. The points used in the presentation mostly correspond to the business development side. The first and third bullets focus on time efficiency, as participants stated that Higgs was time-consuming and suggested a way of saving time. Bullets two, five and seven concentrate on the measurements aspect as the data, the score and the process seemed unclear to them. Bullet six mentions both deliverables and the required budget. Moreover, bullet four mentions that Higg process helped in introducing sustainable development orientation aspect.

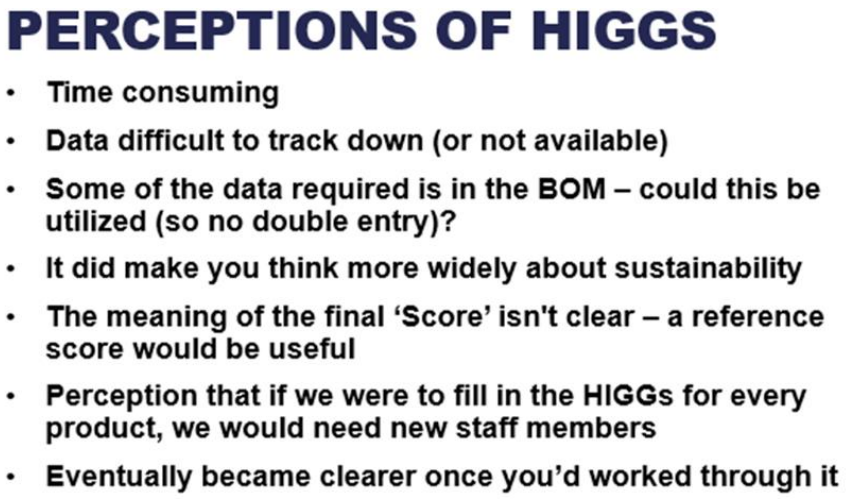


Figure 29. Apparel team perceptions of Higgs index use in the first exercise.

Results communication and desired impact

During the second focus group, participants discussed the presentation of the results of LCA studies and Higg exercise and its impact on the information receivers. The SG summarised the discussion in the following quote:

D: 'The point that [there is a] feeling of empowerment, as mentioned first by the apparel Head. The people will [become] a part of a more robust decision-making process. Usually data don't speak to people that much, but it is important for SG to create a data baseline and to combine it with the empowerment that the data can give to people to make the decisions.'

The expectation of the SG Head was to communicate information that would tell a story about the processes that would help in decision-making process. Based on the previous analysis, it is possible to conclude that only LCA was helpful in providing information brand A hoped to receive, while design of Higgs index allows to provide the same support for the customer give a performance reference number to compare with the other products, while the assessment framework has gaps. Brand A mentioned that they would raise this issue during the next SAC meeting.

5.3.2.3. Summary of sustainability analysis objective use

The success of the presentation of sustainability assessment results depends on the tool that was used during the process. The difference in the acceptance of a certain tool (LCA vs Higgs in case of brand A) is a result of the varying priorities and subsequent information needs in organisational groups and the decisions they need to make. This does not make one tool better than the other, but more or less appropriate for the decisions that need to be made.

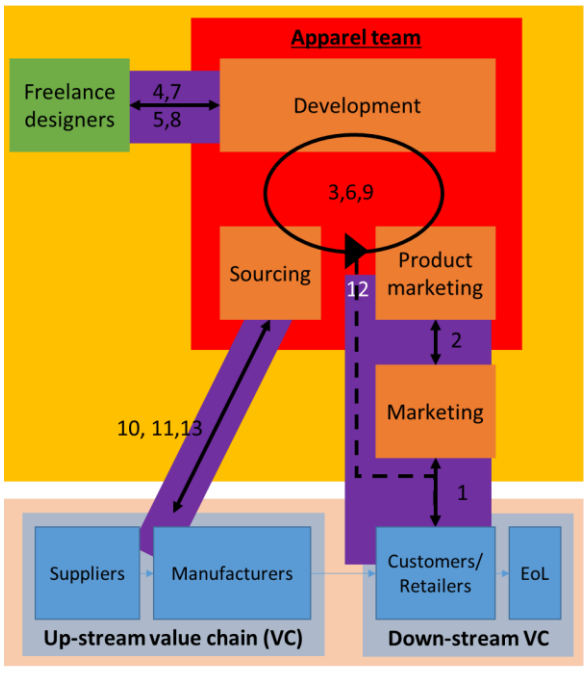
5.3.3. Organisational management and opportunities for integration management objective

The analysis of the connection between the product LC and the organisational processes demonstrated the complexity of integration management objective and the importance of the People layer on top of 3Ps in LCM.

The larger part of the first focus group was devoted to the exploration of the organisational processes to identify how the routines of the apparel team and sustainability aspects reflect the way the team operates.

5.3.3.1. Apparel team collection development organisational process

Figure 30 shows sequential steps of the apparel collection development through the application of cognitive mapping. The raw data for this map was obtained from the focus group on the exploration of organisational processes. Members of all three groups that constituted the apparel team, as well as a marketing representative, participated in this focus group. Another academic partner conducted further research on this topic, including the connections between the existing processes and fit of Higg index in the seasonal apparel collections development process. To assure that the analysis is valid the maps were compared.



Process steps

1. Marketing department conducts market research.
2. Marketing informs apparel team through Product marketing (mainly preferred materials brief).
3. Apparel team comes up with an ideas brief for the designers.
4. Product development briefs the designers.
5. Designers come back to apparel with 50% of collection designs.
6. 50% design analysis by apparel.
7. Apparel gives feedback to designers.
8. Designers utilise feedback and deliver the full collection.
9. Apparel team reviews designs of full collection.
10. Contact the selected suppliers for prototypes.
11. Prototypes delivery to apparel.
12. Prototypes review by apparel and vendors.
13. Preparing the mass production order.

Collaborations

- Intra-organisational
- Down-stream inter-organisational
- Service contractors inter-organisational
- Up-stream inter-organisational

Figure 30. Apparel team collection development organisational process mapping.

The mapping of Figure 30 is based on the distinction between the value chain (VC) stream/product lifecycle in pink color and the organisational process lifecycle in yellow. Therefore, Figure 30 describes these two different lifecycles and their connections in the context of the apparel team. The red and purple boxes show different collaboration (intra-organisational with red and inter-organisational collaboration with purple) in the organisational processes and operations level (except for SG).

Thus, Figure 30 further builds on analysis of the intra- and inter-organisational collaborators, moreover it demonstrates the flow of processes showing links between information processes and info-cycle concept from Chapter 4 (Figure 15).

Below are the quotes from the focus group that were used to construct the first two steps of the process part and a quote for the intra-organisational collaboration of the map of Figure 30. Only two quotes will be mentioned due to the word limit constraints.

1. Marketing department interaction with the market (retailers and consumers). The Marketing representative said:

Ma: 'To gather insights we have a commercial planning process, where we have the different insights of consumers, the newest product technology insights. If that works ideally, we have the different insights and decide. We start with bigger questions: what we want to achieve this season? What is the financial plan? What performance initiatives we have to start? And then we get more insights from countries and all this drive the commercial planning process.'

2. Marketing influences apparel team through product marketing. The Marketing representative mentioned:

Ma: 'We reach design through product marketing and the design process starts. This is how it usually works. I mean in terms of product marketing, the product managers should be also out in the market place to research, provide clues on the design briefs for the designers. What the initial designs to come through to make marketable collections? We check the commercial aspect, analyse numbers, make a short analysis on retail prices. This also includes types of materials to be used (e.g. fabrics, trims, colours), sustainability story if any, etc.'

Based on the results of the interviews regarding organisational process steps the researcher identified four types of collaborations, including the core, or intra-organisational, and three inter-organisational relations that are described in Figure 30. The collected data shows that all these links exist.

There are many ways of seeing that database. However, the accuracy was supported by the analysis of the other academic team, which was focused more on the technical details of the

interaction than the patterns. Unfortunately, due to the length limitations of this thesis, only several quotes will be mentioned.

Intra-organisational collaboration

The intra-organisational processes imply collaboration between product marketing, product development and sourcing groups. Product marketing informs other groups regarding the approach they should use in managing designers and suppliers. Then under the supervision of the apparel team manager these three groups discuss and make decisions on certain aspects of the collection. After that each group works individually with their inter-organisational collaborators.

The intra-organisational processes are the centre, where the inter-organisational processes are attached to. It takes a full cycle, or eighteen months (including intra- and inter-organisational collaborations) to complete a collection, while different cycles are running simultaneously at various stages as the team has to produce a collection every calendar season.

A: 'We are always confronted with the calendar and the deadline. And the calendar is that currently, from the kick off of the season, the very beginning and until the product is in the store. It is taking a time of 18 months under the apparel Head eyes, she is our boss. So this is the cycle, which we all agree, and I saw, I have been a part of some workshops and discussions with other apparel companies on this subject and everybody is brainstorming and trying to bring solutions how to make this cycle shorter. That is the thing. So it is pretty tough because every function needs their time in order to build the product in the creation, so we are now looking honestly into ways to make the cycle shorter.'

A: 'In general, it started with product marketing in apparel, so they are giving the direction, the architecture of the line, are coming from product marketing, but then together with development and sourcing basically we are ensuring that the product is commercial, for all kind of aspects. So this is how it starts, it starting with product marketing, they are initiating.'

These linkages between three LCT types concept were mentioned in Chapter 4. The case of brand A shows that many cycles can take place simultaneously at the organisational processes level to provide the products sequence at the operations level. The way brand A functions seem to be linked to multiple info-cycles and info-complexity flows taking place simultaneously for a different type of products and seasonal collections.

Down-stream inter-organisational collaboration

The marketing department conducts marketing research to provide guidelines on the intra-organisational cycle that help to contextualise and to develop the collection. Also during this cycle, before finalising the details, the marketing staff provides feedback to the apparel team regarding the whole collection. This part involves both intra- and inter-organisational collaboration. The intra-organisational part requires involvement of the marketing and product marketing groups, while the inter-organisational part is the interaction of product marketing and marketing groups with retailers and vendors.

Service contractors' inter-organisational collaboration

During the service contractors' inter-organisational collaboration, the product development group briefs and provides feedback to the designers, and makes decisions on the material aspect of the products. Product development provides the content to the intra-organisational collaboration.

The academic collaborators are linked to another service cycle of collaboration through SAP that is a three-loop cycle. This inter-organisational collaboration type relates to the technocrats (as described in Chapter 4) that are not part of brand A.

Up-stream inter-organisational collaboration

Regarding the up-stream inter-organisational collaboration, by providing guidance to product development, the sourcing group identifies the appropriate fabric and trim manufacturers (second tier suppliers; product parts production) in combination with a garment manufacturer (first tier supplier; product assembly). The sourcing group arranges the prototypes and the mass production of the collection.

It was observed that the collaboration with suppliers was not very close because the brand did not have a steady base of suppliers, which creates problems when the brand has more advanced requirements.

The analysis of the organisational processes showed that multiple organisational processes and multiple seasonal organisational cycles take place at the same time, and this does not allow having any time-space to consider the sustainability aspects of the processes. In theory the integration of Higgs as a process was possible when the organisational level groups would find time to work for it. This made the task from identifying where sustainability should integrate within the organisational processes to find a way to make the organisational processes more time efficient to allow the integration.

As mentioned earlier, the apparel team was trying to improve the processes flow of intra-organisational management to make the process less challenging. During the initial meeting a member of the Cambridge team explained how the automotive industry had simplified their processes [Womack et al. (2007)] to SG Head. The SG Head found the idea interesting and came to the focus group with suggestions towards working in this direction. The SG Head even contacted another business unit to propose this idea to them.

To address the issue of intra-organisational management, during the second focus group the SG manager discussed benefits of setting up supplier alliances and developing more innovative and more sustainable products. The SG stressed that the organisational processes level had too many cycles at the same time while they could be divided into core decisions that require more time (platform cycle) and decisions that are season specific (seasonal cycle). Below are some of the quotes of the SG Head on the platform and seasonal cycles concept.

D: 'We as a company make too many decisions on the seasonal cycle that we chase each other down. If we manage to identify those aspects, if we open the platform cycle by identifying the platform decisions this leaves us time to have more time for the seasonal decisions, this allow to be more adaptive, engage with new consumers.'

D:. 'We are caught up in this seasonal cycle, we are rushing and rushing. We don't have the time for any core improvements' – everyone in the room agreed.

In addition, the product marketing manager added that other members of SAC followed this logic of re-arranging their organisational processes.

R: 'The other companies that drive SAC have this kind of planning/thinking.'

While discussing platform and seasonal cycles approach, the SG manager mentioned some of the benefits that are linked with the intra- and inter-organisational collaboration. However, he presented the sustainability benefit as a side-benefit of improving the other processes.

D: 'When we will have this approach embedded, it will become a lot easier to communicate in a prescriptive way to suppliers [about] what we expect from them. The platform cycle implies that we have a better grasp with manufacturing, [we] understand materials relation with manufacturing, product engineering solutions relate to consumers in this and this way. The seasonal cycle gives the space and freedom to the iterations on the goals related to styles, colours, etc. with that in mind you can go to suppliers and say this is our work, this is the design and this is how it relates to manufacturing. That is the logic.

From sustainability point, for example we want to reduce waste impacts, we can achieve that only if we understand manufacturing. This is how sustainability and performance relate, you need to understand how things work and feel each other'.

Taking into consideration the information on the organisational processes, brand A accepted the platform and seasonal cycles concept, the CIS team linked Higg index tool separation at brand and product levels and identified the links between sustainability issues and the platform level. The separation of Higg index will provide an opportunity to introduce sustainability aspects into the decision-making process. At the moment of the analysis the busy organisational cycle did not allow to spend time and efforts on the sustainability aspects because the members of the team were forced to make so many unique decisions at the business level for each collection.

This platform/seasonal platform development proposes a new organisational process (a new way of managing the material library) that aims to support the decision-making at the product level. A material rating system and a strategy to use materials of preferred performance and maintain space for creativity were also proposed. Also, a framework described in Figure 31 showed how the material library could be linked with the platform and seasonal cycles.

The Head of product development commented on the way apparel came up with the material choices every season and loss of time due to the absence of a material library, therefore, every season the process of collection started from the beginning and finished with using very similar materials to the previous seasons.

A: 'If for example a fabric database [that] you fill automatically can be linked to Higgs, saying: 'You use this material, here is the score.' We cannot go back and see what materials we were using because we don't have a library. In some we have some details but it is very unclear. What we want to achieve is to have more carry overs and new fabrics every season. When we are starting a new season and checking the materials at the same time we are closing the previous season, so there are overlaps with the material brief we are busy, the new season is so picking.'

The process described in Figure 31 proposes a decision-making model based on a platform cycle, where 75 percent of the materials does not change from the previous seasons, while 25 percent are new material entries. This model can save time in the process of material decisions and will also give space to decide on the sustainability aspect of these decisions. The SG Head supported this idea.

D: 'The materials system that you propose is what we really need it give the whole decision-making quite a clear direction, it basically clarifies where the platform cycle kicks in what that entails, that entails a more thorough review separate from seasonal cycles and basically can be continuous'.

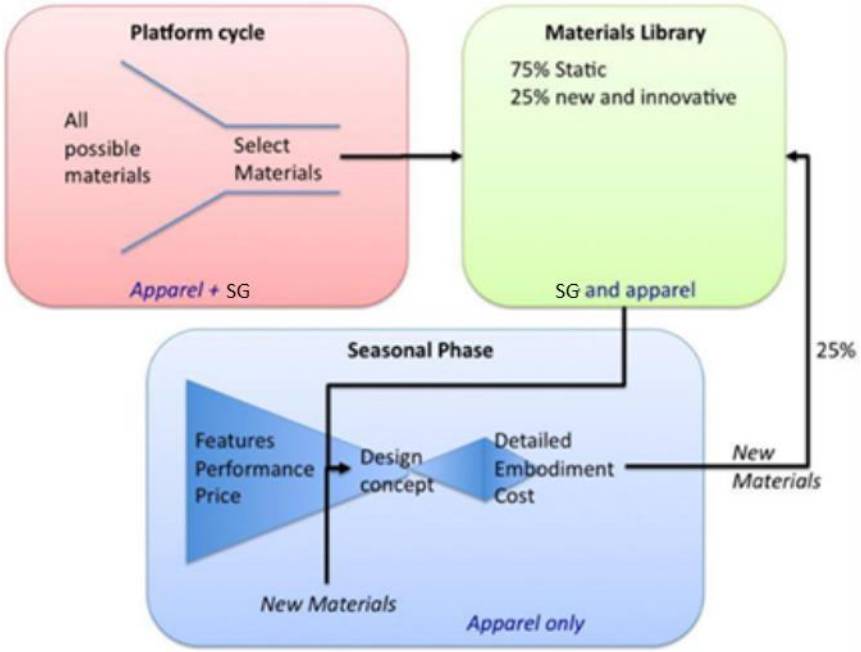


Figure 31. Material library with material inputs from the platform cycle and seasonal phase.

In the available LCM literature, the analysis of the organisational processes has not been conducted before and this case allowed to prove that this analysis could be very helpful in the development of integration management objective.

5.3.3.2. Info-diversity focus by organisational group

The sustainability strategy of a company might seem as a straightforward task. For example, the task of emissions reduction is linked to the production of a product. To achieve this task, the SG, which is a supportive organisational group, has to influence the decision of many core organisational groups to make changes. This is a complicated process.

The analysis of decisions made at the organisational processes level by the rest of the organisational groups shows that the info-diversity conceptual framework (that introduced the 3Ps layers in Chapter 4) becomes a very complicated puzzle where each piece links with an individual from an organisational group that has to make an informed decision at the people layer that is described with the info-complexity conceptual framework (that is linked to info-diversity). Each individual representing an organisational group has a different focus blend on the VC, 3Ps, and TBL analysis lenses of info-diversity. This is an attempt to analyse the apparel team groups coverage at the value chain, 3Ps and TBL levels.

Value chain, 3Ps and TBL focus on each group covers a different aspect of decision-making. Value chain focus shows the influence of each group's decisions in the VC, 3Ps reflects the layer that each decision is focused on, while TBL considers the aspects that each group considers. Table 25 describes the VC coverage of the groups assessed.

Table 25. Intra- and Inter-organisational decision-making flow and analysis lenses.

		SG	Product marketing	Product development	Design contractor	Sourcing
4Ps	People	√	√	√		
	Product	√	√	√	√	√
	Production Processes	√		√		√
	Place	√				√
TBL	Business	√	√	√	√	√
	Environmental	√	√	√		√
	Social	√				√
VC	Suppliers	√		√		√
	Manufacturers	√		√		√
	Retailers/ customers		√		√	
	Eol					

Table 25 describes the complexity of the sustainability-related decision-making processes and connections between them. The table used the data on mapping the organisational cycles and specific interview questions on the value chain, 3Ps and TBL. Vertically the Table addresses factors of the info-diversity complexity and follows the 3Ps, TBL and VC analysis lenses described in Chapter 4. Horizontally the table follows the info-complexity flow (also described in Chapter 4) and shows actor's sequence as described in Figure 30. Table 25 shows that at the organisational level information does not flow simultaneously, but there is a gradual information flow process.

The apparel team did not focus on environmental and social issues in the beginning of the project. However, during the project the apparel team groups started addressing environmental and social issues.

Focusing mostly on the upstream part of the value chain, the SG influenced other groups to take sustainability-related action at the product layer and some actions at the process and place layers. At all these layers the primary focus was on working on the people layer by encouraging them to integrate the aspects in their decisions. According to SG, the people level was key as it is used to influence others to take action on the 3Ps layers inside and outside the organisation. At TBL aspects the approach of SG was different for every layer; the SG approach was implemented through collaboration with different groups on different aspects of the info-diversity conceptual framework. As a result of SG interaction with the apparel team the following actions were taken.

For the product marketing (PM) role, the focus was on how the company could create marketable products. Usually, most the PM decisions were made in regard to the types of materials that should be used for each season. PM started considering sustainability aspect, i.e. sustainability of the materials used (for example, suggestion to use recyclable materials). In this case product marketing paid attention to the product layer and the environmental aspects by focusing on the assembled product that the manufacturer VC stage should produce to have a successful product in the retail/customer VC stage. PM created ideas of marketable products, which represents the link of down-stream VC with the up-stream. Product marketing acted at the people layer – organisational process to influence the up-stream value chain through the apparel team people. The way product marketing influences action is by inducing people that make decisions at the 3Ps level. This role is focused primarily on the

cost/business aspect, and then on the environmental targets without any concentration of the social aspect.

The product development (PD) group was focused on the up-stream VC side, in particularly on finding the right materials and execution for each garment in accordance with the guidelines of product marketing. This made PD active at the product and processes layers. Moreover, PD acted on the people layer to influence the designers to develop designs that were producible at a logical cost and to influence sourcing to provide suggestion on sustainable material options and to consider the sustainability of the suppliers at the product and processes layers.

The (design) contractors designed the product to satisfy the needs of the down-stream side but at the same time the product was supposed to be in the range of the technical and costing limits of the up-stream side. There were no decisions that could be linked with sustainability, while sustainability was considered as an issue that blocks creativity and was addressed by PD at a later stage. This perception of sustainability at the design stage gives an idea on how the company prioritised sustainability compared to other organisational strategies.

The task of the sourcing (S) group was to identify the raw material suppliers and garment manufacturers who would provide the required quality of execution at a desired cost. By definition, the focus of the sourcing group was on the up-stream VC part of the value chain and manufacturing processes. Sourcing and PD groups collaborated at the product and process layers to improve sustainability performance, for example, in the development of more sustainable fabrics, better marker efficiency, etc. The decisions in regard to the place layer depended on the suppliers' market trends that were not set by the company: decisions depended on the location of the most attractive offer. The sourcing group considered the sustainability aspects of location, as there were several 'no go' areas or suppliers blacklisted by the SG. Except for SG, the sourcing group can be considered as the only team that addresses all three TBL pillars.

By considering the individual organisational process actors analysis (mentioned in Table 25) and by applying aspects of info-diversity and info-complexity conceptual frameworks, the researcher was able to observe that SG tries to influence the rest of the organisation, focused only on the upstream side of the VC while not paying attention to the EoL at all; at the same

time in the retailers/customers VC stage SG mentioned only some ideas that would not be part of their work in the near future.

On the People and 3Ps layers (4Ps), SG tried to influence the actors who can have an effect on the rest of the functions to take action, including PM affecting products, PD guiding processes and S deciding on Place.

On the TBL aspects, SG did not focus on costs while other group members paid attention to cost, they tried to make suggestions at the processes/business level about the platform and season idea. In regard to the environmental pillar, SG worked with PM and PD on the product, and PD and S on processes. At the social pillar they involved S exclusively at the Place level. This shows that the sustainability information flows was spread across different organisational levels (which is reflected in the info-diversity and info-complexity conceptual frameworks), and they had limited information flow interactions.

However, the influence of 3Ps and TBL analysis lenses focus blend varies with different group and role. It is interesting that according to one SG person, when considering 3Ps SG focused on products, while according to another interviewee, SG paid attention to process auditing. This can be explained by the different intra-SG

tasks focus of the interviewees. The researcher made suggestions to the SG to expand their VC focus to customers, retailers and EoL. In particular, it was suggested to improve logistics and to introduce better processes timing (to avoid air-freight). The second intervention was to explore the use phases of the product. The LCA allowed to identify the second largest environmental lifecycle impact, and the research team advised the apparel team in collaboration with the marketing team to find ways to influence the consumers to use the washing machine in a more eco-efficient way. The third impact was related to the EoL management of products: for example, the SAP team (apparel and SG) was asked to consider other options for waste products, except for land-filling. Nevertheless, the SG decided to pay attention to these suggestions at a later point as the main challenges to be addressed were in the upstream part of the VC.

5.3.4. The importance of developing knowledge

During the revision of the work so far on the LCM factors based on the LCM literature cases analysis and Case A, the researcher realised that the developing knowledge factor is a core aspect of LCM that the current LCM literature has not paid much attention to.

The situational need to improve understanding (aka 'develop knowledge') was a common part of the various situations analysed. It is also supported by the general knowledge development literature [such as Nonaka and Takeuchi (1995), Dixon (1999) and Bhatt (2000)] which explains why knowledge development is so important in situations where new concepts are introduced into organisational processes. The researcher argues that the studied situation is similar to this (i.e. ambiguous, multi-functional, no known solution, etc.).

From section 5.3.1 on the fit of the LCM factors across Case A, we can see that SAP's development was closely linked to the need for developing knowledge on sustainability aspects.

In addition, the revision of the sustainability analysis and integration management aspects in Case A make apparent that the developing knowledge factor was critical in the development of the two LCM objectives during Case A.

The sub-sections below describe the developing knowledge factor focused analysis of Case A timeline, the development of the sustainability analysis and integration management objectives.

5.3.4.1. Developing knowledge though the SAP LCM factors analysis

SAC was formed by apparel companies to face a sector's highlighted problem that companies had limited knowledge. For the same reason SAC and SAP had academic institutions as key collaborators in programs that aimed to enhance the state of knowledge of the organizations on sustainability and inform their decision. SAP started only when the apparel team was in need of the knowledge. And when the participants were reviewing the process quoted that 'we now feel that they have to learn more because there are many things that we did not know' (development group representatives) while Apparel Head and Marketing representatives highlighted the need for participating and let the knowledge ball rolling.

5.3.4.2. Developing knowledge through the application of the sustainability analysis objective

The examination of the sustainability analysis objective of LCM helped the researcher to see how LCM factors fit in the management decisions that were being taken. Below are some examples of how each LCM factor fit:

- Highlighting. Comes from the need of analysis to obtain information and knowledge about certain conditions necessary when supporting a decision. In this case, the SG needed product LCA studies to identify areas for improvement and to support SAP progression.
- Collaborating. Both intra- and inter-organisational collaboration is a key part of assessment and analysis, as many actors participate in providing data and even specialists can be summoned to conduct the study in case there is no capacity within the organisation. In this case, the SG had to collaborate with the apparel team and their suppliers to provide the data, and invited the researcher to conduct the LCAs. The underlying reason for collaborators to contribute in LCAs was to obtain knowledge.
- Analysing. This refers to the analysis of the assessment options such as different LCA types, Higgs index, etc. which pointed the different directions the developing knowledge could take.
- Strategising. Each analysis is aimed at achieving a certain goal, at comparing, and at analysing a specific part of the VC or all of it, etc. In this case, the strategy of the SG Head was to focus on the whole VC, to create the most accurate model with available data and to identify hotspots to focus the research.
- Decision-making. Depending on the strategy, the person(s) who conduct(s) the study make specific decisions to realise the strategy. In this case, to fulfil the strategy it was necessary to make a decision in regard to the focus of the research. As a result, the team focused on three typical pieces of garment. Moreover, in order to conduct an accurate analysis, the researcher decided to introduce the 3Ps approach instead of using available models of the LCA software.
- Implementing is the process of conducting the study. In this case, implementation included the process of data collection, the development of the model and the analysis.

- Sustaining allows to transform the analysis attempts that started as a project into process. In this case, the LCA project of three apparel items became a process that takes place every two or three years.
- Developing knowledge. Each LCM stage usually provides new knowledge and questions to be explored. In this case, the LCAs provided knowledge about the performance across the VC and highlighted some areas that required more detailed analysis. This guided the next LCM cycles to develop more knowledge or to inform the process, to skip VC parts from the analysis because currently there is no potential of performance improvement.

It seems that the fit of the LCM factors in the application of sustainability analysis objective in case A is accurate. Moreover, the underlying fit of developing knowledge across sustainability analysis was apparent.

5.3.4.3. Developing knowledge through the application of the integration management objective

Through the analysis of the LCM integration management (objective 2) the researcher proved that LCM factors introduced in Chapter 4 correspond to the management decisions that were taken through the organisational processes level. The SG made some management decisions at the intra-group and intra-organisational levels, while inter-organisational collaborators made their decisions on the integration of sustainability. Below are some examples illustrating how each LCM factor correlates with objective 2.

- Highlighting. It is triggered by the need of the non-sustainability groups (non-SGs) to take action on sustainability while they do not have the competencies to proceed. In this case, non-SGs did not have enough knowledge to integrate sustainability into the organisational processes and to adopt the Higgs index process. However, they were driven by external factors discussed earlier to introduce sustainability concepts in their practices.
- Collaborating. Both intra- and inter-organisational collaboration plays a vital role. In this case, the SG had to collaborate with:
    - the apparel team to assess the current situation, to provide training and support to the apparel team, and

- with academic consultants to conduct the analysis and to provide suggestions.

- Analysing. The academic consultants mapped the organisational processes, identified the focus for each group and identified improvements. This helped to focus interactions of SG with each organisational group to integrate sustainability into organisational processes in a more efficient way.
- Strategising. The SG used the sustainability analysis information about risks and opportunities and potential improvements for the process to influence action. The result was the four pylons of action described in Figure 18.
- Decision-making. Under each action pylon of Figure 18, the SG had decided a list of actions. Moreover, the non-SGs took time to consider if they would follow the suggestions. In this case, some proposed interventions were approved, postponed or denied. When certain suggestions were approved, they made more specific decisions regarding the implementation.
- Implementating. The non-SGs or their collaborators took action at the operations organisational level across the VC.
- Sustaining. In cases of malfunctioning, SG took the lead to find a solution or to learn from it. For example, SG identified the lagging part of Higg index and was working on some more creative processes. Also, through the introduction of the seasonal and platform cycles concept, SG proposed to create the time-space for other groups to focus on sustainability. Furthermore, SG sustained links to the projects development to processes, this was the case with some of the proposed interventions.
- Developing knowledge. SG learns from success and failure, and tries to adopt the business development philosophy to enhance the sustainable development philosophy for the non-SGs. This leads the follow-up steps of integration management and also relates to the leadership part of the sustain factor. In this case, for example, the Stage I LCA studies showed that the manufacturing part contained the main environmental hotspots. This knowledge guided SAP to focus their attention and LCA studies on more specific parts of the manufacturing process. The obtained knowledge and its application to obtain better results is a part of LCM with very limited knowledge on the performance of this 3Ps layer.

It seems that the fit of the LCM factors in the application of integration management objective in case A is accurate. Again, we see here the core importance of the developing knowledge factor.

5.4. Conclusions – LCM factors and three objectives relation

This case was informative and helped the researcher to explore ideas introduced in Chapter 4 in action. Based on the available information it is possible to conclude, that eight LCM factors mentioned in Table 14 and linked to this case context through Table 19 are valid and continuously appeared in each stage of SAP. This finding seems very important for the development of an LCM framework.

The Highlighting factor initiates each stage of SAP. It was initiated as a result of analysis, crisis or decisions made at the intra-organisational or inter-organisational levels of the company. When this factor is related to the priorities of the decision-making people, it plays a crucial role in involving other parties.

The Collaborating factor is fundamental to the development of LCM. Collaboration is essential in obtaining data for the analysis, as well as during the implementation of projects or processes inside or outside the company.

The Analysing factor is crucial, because the information and knowledge produced as a result of this factor are fundamental for decision-making. This factor helps in identifying the risks and opportunities, proposing solutions and setting the discussion on the causes and solutions.

The Strategising factor is essential for guiding analysis, implementation and development. Through this case, it became apparent that lack of clear strategy could misguide implementation.

The Decision-making factor plays an important role for implementation. The case showed that the integration of sustainability aspects in decision-making is complicated, and the ideas of the researcher helped to analyse this complexity.

The Implementing factor is important for developing the knowledge and engagement of participants since it provides them with experiences and new knowledge.

The Sustaining factor focuses on the continuous improvement and leadership towards integrating sustainability aspects into organisational processes. It does not only focus on developing processes as it was mentioned in Table 14, but also helps to and leads the process of improvement.

The Developing knowledge factor improves knowledge through analysis and implementation of the experience to lead the sustainment of integration. It seems that developing knowledge is the key factor of LCM as it is essential for influencing and developing the previous factors in the next cycle. The importance of learning factor became a trigger for the researcher to explore further the influence of knowledge management providing for integration of sustainability aspects in organisational processes. This decision is aligned with the discovery of the People layer as an addition to the 3Ps proposal. The learning (developing knowledge) factor was linked with influencing and developing the knowledge on integrating sustainability aspects into organisational processes. As in most of the cases, the SG played a supportive role while the central cycle groups were responsible for the integration.

Moreover, during the data analysis on LCM factors fit with SAP certain things that are new to the LCM literature were mentioned. Some of addition are:

- The inter-organisational cooperation is two-dimensional; across the VC (horizontal) and 3Ps layers (vertical).
- Sustainability priorities compete with other intra-organisational priorities and If highlight factor priority changes for collaborator, the collaboration potential changes.
- When the message of the sustainability strategy is more clear and measurable there are better chances for other organisational groups to adopt it.
- A description of the other group members' intention to participate in a sustainability project is described.
- Implementation difficulties and also what did not work well was mentioned.

In addition, it seems that except for the fit of LCM factors with SAP's stages, there is also a relation with the LCM factors and objectives application (both sustainability analysis and integration management objectives). The continuous improvement objective was not assessed in this case, but it was present during the application of the other two objectives. For example, in case of highlighting factor, SG usually identified certain aspects that required

further improvement. Moreover, in case of developing knowledge factor, there were lessons learned from the application of previous factors and the enhanced knowledge usually created new risks and opportunities that further improved sustainability integration.

As to the sustainability analysis objective, the 3Ps layers separation and info-diversity conceptual framework described in Figures 11 and 12 are useful as there was no process of separating these layers at the data collection stage and the decision-making allocation as well. The concept provided by the researcher can help in connecting the data collection with the specific decisions, especially in cases, when there is no data collection framework and decision-making allocation framework. The info-diversity conceptual framework helps the sustainability professionals to map the sustainability analysis context in its three layers (3Ps) and their relation with TBL/VC and to identify blankspots (areas in the LC with missing information that can be divided into two categories, including minor [low influence] and major [potential of high influence]). For example, in this 3Ps layers helped identify inefficiences during the LCA process and find Higgs blankspots.

On the integration management objective, the diversified information needs to be directed to the appropriate decision makers. The variability of decision-making allocation requires a different type of information to effectively inform the integration of information in these decisions. This points to the different need of analysis result presentation as the information complexity that was introduced in Figure 15 of Chapter 4 and this case analysis described in Figure 30 showed that information allocation should be in accordance with the info-complexity. The info-complexity conceptual framework assists the sustainability professionals to map the current or potential intra-organisational information flows that are linked to the info-diversity, and acquired knowledge can help to develop and to direct the appropriate information to the appropriate decision maker.

This case allowed to demonstrate that the TBL and 3Ps analysis information flows are not parallel within the organisation, and this shows that integration of sustainability information plays an important role. This was observed from the interviews on different decision-making among SG, product marketing and product development groups. This was also reflected in the different perception of Higg index by SG and apparel team. This type of information helped during the assessment to find out that these flows of information are not parallel, but did not provide information on the specific areas of improvement (in accordance with SG

person understanding). It is important to know that the TBL pillars information usually are not parallel and different pillar decisions take place in different parts.

Furthermore, it is very important for the sustainability professionals who are interested in communicating information to the decision makers at the other organisational groups to pass the information in the right format. The information should be comprehensible so it could be considered and applied during the processes requiring sustainability-related information. In this way, the sustainability professional will provide information that will allow the decision maker to understand the sustainability perspective and will lead to the integration of information in organisational processes. In cases when the sustainability professional can make connections between the sustainability information and the priorities of the decision-makers, the leading process might be even more successful.

As to the LCM management cycles, it could be concluded that the project and process management aspect exists in LCM, but it is not explored. There are intra-organisational and inter-organisational cycles in the organisations that are not explored in the literature. The intra-organisational cycle plays the central role since the decision-making is happening during this cycle, even when the decisions that are heavily influenced by the inter-organisational stakeholders (like the up-stream cycle of the case), when the decisions on the initial product brief were made by the marketing group. That importance of the intra-organisational cycle also was demonstrated through the introduction of the idea on separating the central cycle in the platform and seasonal cycles to allow space for the development of the aspects that are not included in the core business/product focus and develop synergy across the different 4Ps levels. The mapping of this cyclical process and the collection of the learning during each cycle can help with the continuous improvement objective through application of this knowledge and enhancement of the integration in the future cycles.

The importance of the leadership aspect in the implementation and sustainment of projects and processes was another angle that came from this case, while the knowledge development is the key ingredient in the integration of sustainability because of its knowledge integration ability.

The info-diversity concept helps the sustainability professional to map the situation from a sustainability perspective using the 3Ps layers. The info-complexity concept helps the

sustainability professional to link the sustainability perspective with the business processes perspective and to relate the 3Ps related information to the people (4th P) who are supposed to make the decisions that will enhance the sustainability performance. Moreover, the knowledge of the sustainability professional about the type and style of information presentation and priorities of each decision maker can lead to a more targeted and efficient information integration process. Last but not least, the observation of the LCM cycles and the identification of the areas of weak knowledge can help to lead the next cycles towards enhancing the knowledge and related information flows and processes towards improving the sustainability information integration and the related sustainability performance.

This case demonstrated that all LCM processes were aimed at enhancing knowledge on sustainability through knowledge development, with sustainability analysis objective focusing on the sustainability professionals and with the integration management objective on the non-sustainability professionals who should consider sustainability information in their decision making. This case also showed that continuous improvement objective and the application of the obtained knowledge to improve the sustainability integration in the organisational processes deserve further research and analysis. The continuous improvement of knowledge noticed here relates to the info-cycle that Figure 15 introduces. From this case seems that info-cycle as a continuous improvement concept links sustainability analysis (info-diversity) and integration management (info-complexity).

The purpose of LCM is to manage the product and organisational processes lifecycles and the key that unlocks good LCM performance might be developing knowledge. The researcher highly believes in the importance of developing knowledge factor as a promising way for sustainability professionals to think about their role and to improve their actions.

6. Knowledge management literature review

This chapter explores the Knowledge Management literature and identifies concepts that may help the researcher in analysing the developing knowledge factor.

6.1. Introduction to second literature review

In the beginning of this research it was known that the continuous improvement objective builds on sustainability analysis and integration management objectives. That is the reason of limited focus on the continuous improvement objective in Chapter 4. In Chapter 5 the researcher explored the application of sustainability analysis and integration management objectives in case A, and through the examples from case A the researcher showed that continuous improvement was linked to continuous enhancement of knowledge on sustainability. Moreover, the researcher observed that both sustainability assessment and integration management objectives were aimed to increase the sustainability knowledge by informing the sustainability professionals on the condition and non-sustainability persons who should consider sustainability information in their decision-making.

For these reasons the researcher decided to explore the knowledge management (KM) literature. Through KM literature the researcher will demonstrate the factors that influence the continuous improvement objective of LCM, which will aid the development of a framework that could help corporate sustainability managers and strategists to map and to enhance the application of continuous improvement objective in LCM.

6.2. Literature review method

The second literature review was a combination of snowballing and researcher's decisions. The following steps were followed to conduct this literature review.

a. An initial search was conducted to identify LCM papers that included concepts from knowledge management. This combination was chosen based on the output from the first analysis which emphasised in many parts the important role that knowledge and its development was having. The search returned three publications; Poikkimaki (2006) introduced the concept of knowledge creation (SECI), while Nilsson (2013 &

2014) introduced the concepts of knowledge management and capabilities development.

b. The researcher decided to snowball these publications. This created two streams of research:
    i. From Poikkimaki (2006) most of the attention was focused on Nonaka and Takeuchi (1995) that introduced their SECI model to discuss the development of information toward knowledge and the researcher was intrigued to study these constructs. This decision also led to research into the literature for other knowledge constructs (such as DIK). The research return different concepts
    ii. Nilsson (2013 and 2014) was very critical of KM without using lots of KM related references. The researcher decided to explore more about KM through KM reviews and while reading Dalkir's (2009) KM review, discovered IC. As IC points to effective use of knowledge which points to both KM and capabilities, the researcher decided to explore the IC concept further.
c. Both the IC and SECI models for knowledge management were found to be substantially represented in the literature and used by many practitioners and researchers, which offered some early confidence to this researcher that the concepts were useful, even if not yet shown to be useful in the LCM context.
d. A literature research was conducted on 'IC and LCM', but there was not any result. Then tried 'IC and sustainability' limited to 2013-2017 and 50 results came out. The researcher read the abstracts and realised that most of the papers did not have IC as their main concept and decided to limit the research to the papers coming from IC related journals and the results dropped to four. Of the 4 only Wasiluk (2013) was focused on corporate sustainability, the rest were focused on cities, cultures, etc. This single paper highlights the link between corporate sustainability and IC, however, out of the 98 references only 11 were IC related references, and 8 out of the 11 were core IC papers. The researcher decided to snowball these 8 core IC papers to explore the IC field.

6.3 Knowledge management (KM), intellectual capital (IC), and LCM

Three KM concepts that could have potential to advance the developing knowledge factor of LCM: the adoption of knowledge in action knowledge construct, the consideration of organisational knowledge creation model, and use of IC concepts.

6.3.1. The Knowledge Age

Peter Drucker (1964) introduced the term of a 'knowledge worker' to describe a new type of worker in the organisation. Davenport (2005) discussed a transformation through time that happens in any organisation from labour-intensive manufacturing to knowledge-based organisations. For organisations striving to become more efficient, this transformation requires bypassing of organisational hierarchies and interconnecting collaborations allowing to benefit from use of the knowledge that exists in the different organisational groups. The organisations can take advantage of actions, such as provision of the best available information, knowledge and know-how (Davenport and Prusak, 2000). In this context, a company has to learn to become more efficient with existing knowledge to avoid (re)invention of the wheel every time when similar knowledge is needed, as most knowledge that might be required, already exists (Schimpf and Roth, 2002).

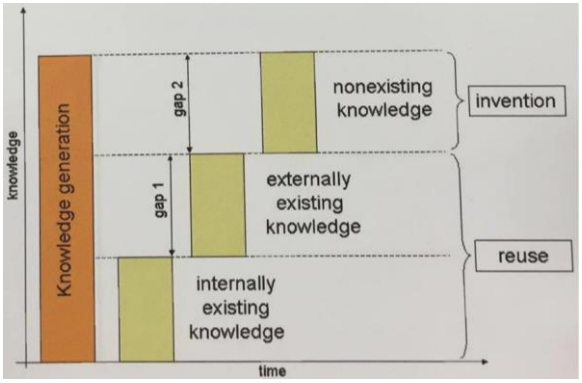


Figure 32. Knowledge generation (Schimpf and Roth, 2002).

6.3.2. Knowledge management

Knowledge management is a systematic approach that allows to capture, to structure and to disseminate knowledge through the organisation (Nonaka and Takeuchi, 1995; Davenport, 2000; Dalkir, 2011). According to Wiig (2000), two aspects are crucial to the success of knowledge management, the knowledge assets and the knowledge processes. Both assets and processes must be preserved, used, adapted and organised. Knowledge management is

the process of continual administration of knowledge of all kinds to meet existing and emerging needs of the organisation, to identify and to exploit existing and acquired knowledge assets and to develop new opportunities for production of knowledge (Quintas et al., 1997).

The key knowledge management literature focuses on knowledge constructs (i.e. Davenport, 2000) and knowledge creation mechanisms (i.e. Nonaka and Takeuchi, 1995). This mechanistic approach is in line with Hilsop's (2005) knowledge transfer approach which is based on an information transmiter and a receiver approach. Nevertheless, some publications, such as Orlikowski (2002) and Nicolini et al. (2003), are questioning this mechanistic approach of knowledge transmission while supporting knowing as a process based on the ongoing relationships and the experience that is acquired through practice. The mechanistic approach will be described below while the action based approach will be covered in the intellectual capital section.

6.3.2.1. Knowledge constructs

The adoption of the knowledge management constructs and especially the knowledge in action construct can help in exploring application of sustainability knowledge in the organisational processes.

Knowledge is a way of learning that is typically built on the information based on data (Henry, 1974). These three constructs, data-information-knowledge (DIK), usually applied in a discussion of knowledge management, form the base for putting knowledge management in context. Some researchers suggested additional knowledge constructs, including wisdom, insight, resolve (Cleveland, 1982; Ackoff, 1989), and knowledge in action (Davenport and Prusak, 2000).

The researcher decided to use Davenport and Prusak (2000) additional knowledge construct of 'knowledge in action' and apply it in the context of knowledge management because these authors took into consideration the importance of organisational aspects which are represented in other approaches to the lesser extent. Knowledge in action could serve this research since the focus of this particular research is on organisational processes. The knowledge management focus on wisdom, insight and resolve have influenced factors that

cover specific aspects of organisational processes. Overall there are few researchers looking into the action aspects of knowledge management, the only researchers who discuss knowledge management context under the action angle is Davenport and Prusak (2000).

Below the author presents an analysis of the 'DIKA (Data-Information-Knowledge-Knowledge in Action)' knowledge constructs concept as described by Davenport and Prusak (2000) and the DIKA components are described in Table 26.

Data is a description of facts in a detached and objective way. Data are unprocessed facts that in current form cannot support the judgement, cannot show the importance and relevance of facts to make suggestions or conclusions.

Information is the outcome of data processing that aims to raise the understanding of data relations and put a structure that will help in drawing conclusions at a later stage (information provides answers to questions 'who', 'what', 'where', and 'when') (Cleveland, 1982; Ackoff, 1989). Information contains a message for the receiver and information shapes the way the receiver perceives specific fact(s). The receiver makes judgements based on the message of the information and characterises the message as useful or noise. Data becomes information through value creation.

Knowledge derives from information as information derives from data. When information is to become knowledge, people do all the work virtually. Knowledge is a synthesis of framed, evaluated, contextualised information, intuition and expert insight that originates and is applied in the mind of knowers and helps them to evaluate and to incorporate new experiences and information.

Knowledge in action is analysed data patterns that supports decisions and actions. Knowledge can be evaluated by the decisions and actions it leads to. Knowledge and decisions usually exist in people's mind.

Table 26. DIKA components (Davenport and Prusak, 2000).

Components		Description
Data		unprocessed facts
Information (value creation)	Contextualisation	data gathering happened for certain purpose
	Categorization	the units of analysis or key components of the data are known
	Calculation	the data may have been analysed mathematically or statistically
	Correction	errors have been removed from the data
	Condensation	the data may have been summarised in a more concise form
Knowledge (transformation)	Comparison	how does information about this situation compare to other known situations?
	Consequences	what implications does the information have for decisions and actions?
	Connections	how does this bit of knowledge relate to others?
	Conversation	what do other people think about this information?
Knowledge in action (knowledge use)	Experience	refers to what an individual or group has done and what has happened to them in the past.
	Ground truth	implies knowing through experiences of the others what works and what does not.
	Complexity	ability to deal with complexity and to acknowledge fragments that make the puzzle in the name of certainty without considering consequences.
	Missed knowledge	knowing that certain fragments of the puzzle are missing.
	Judgement	ability to judge new situations and information in the light of what is already known.
	Rules of thumb	imply shortcuts to solutions for new problems that are similar to problems previously solved by other people.
	Intuition	insight expertise, learning steps that happen unconsciously and therefore very quickly that is based in previous experiences.
	Values and beliefs	they have a powerful impact on organisational knowledge, as they inescapably influence their thoughts and actions. Under the same conditions people with different values see things differently and organise their knowledge in accordance with their values.

6.3.2.2. Knowledge creation mechanism

The consideration of the knowledge creation mechanism can help in exploring how sustainability knowledge is created through LCM.

Knowledge creation mechanism is the subject of knowledge philosophy. Nonaka and Takeuchi (1995) spiral of organisational knowledge creation has set the base for discussion on this

subject. As described in the Figure 33, the spiral is analysed in two dimensions, the epistemological and the ontological.

The epistemological dimension refers to two forms of knowledge. These two forms of knowledge relate to the theory of tacit and explicit knowledge of Polanyi (1966) that Nonaka and Takeuchi (1995) applied to explore knowledge development in organisations. Tacit knowledge is a complex concept as it is subjective and it exists in the mind of knowers and sometimes it is difficult to externalise tacit knowledge to others. Explicit knowledge has content that makes it tangible and thus easy to share with others.

The ontological dimension relates to the knowledge creating entities. According to Nonaka and Takeuchi (1995) and Dalkir (2011), in the organisational context knowledge can be separated into three levels: individual, group and organisational levels. The individual knowledge is the knowledge that 'walks out the door at the end of the day and returns the next morning' (Drucker, 1964). Managers often do not have a process on how to handle this knowledge (Lesser and Prusak, 2001). The group and organisational knowledge refers to the collective learning that is the result of the social relations that members of the society form at different levels to achieve common targets; the group and organisational levels are also termed as communities of practice (Wenger, 1998).

Tacit knowledge	Explicit knowledge
Subjective	Objective
Experience	Rationality
Simultaneous	Sequential
Practice	Theory

Knowledge conversion modes (SECI)	
Socialization	From tacit to tacit
Externalization	From tacit to explicit
Combination	From explicit to explicit
Internalization	From explicit to tacit

Knowledge conversion triggers	
Dialogue	Socialization → Externalisation
Networking	Externalisation → Combination
Learning by doing	Combination → Internalisation
Field building	Internalisation → Socialization

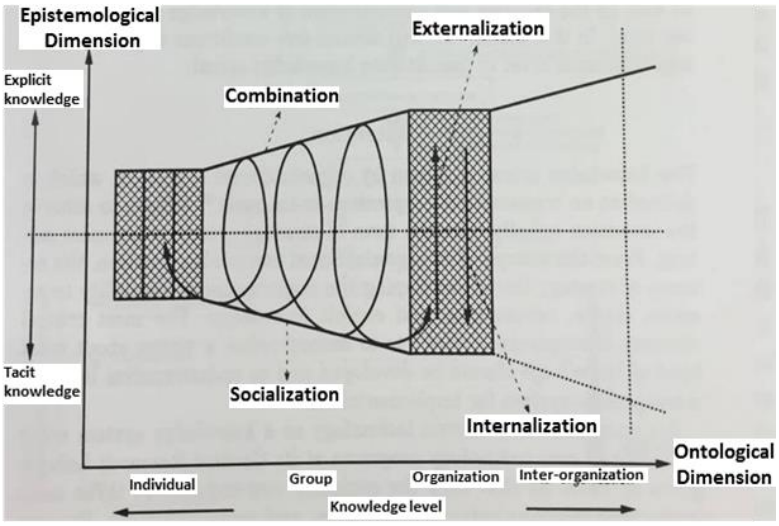


Figure 33. Spiral of organisational knowledge creation (Nonaka and Takeuchi, 1995).

According to Nonaka and Takeuchi (1995), knowledge is a result of interactions between tacit and explicit knowledge. The conversion from tacit to explicit has a continuous cyclical (spiral) flow that is comprised of four modes of knowledge conversion (SECI; starting from

socialisation and finishing with internalisation) that appear in the organisation's groups and the organisation knowledge levels. The interaction between different modes of knowledge conversion is caused by specific triggers (e.g. dialogue) for each mode conversion.

Traditionally, the SECI model that shows the knowledge conversion is described with a spiral flow. However, when observing the flow of triggers cause knowledge conversion in Figure 33 the flow of triggers has a shape of an infinity loop. The spiral usually starts from sharing knowledge about previous experience with other members of the group at the organisation level (field building). Then, this knowledge triggers a more meaningful discussion that helps to articulate tacit knowledge that was hard to communicate (dialogue). After that tacit knowledge that becomes explicit, flows in the organisation (networking). In the last segment of the spiral, the obtained knowledge triggers a new spiral cycle (learning by doing).

6.3.3. Intellectual capital

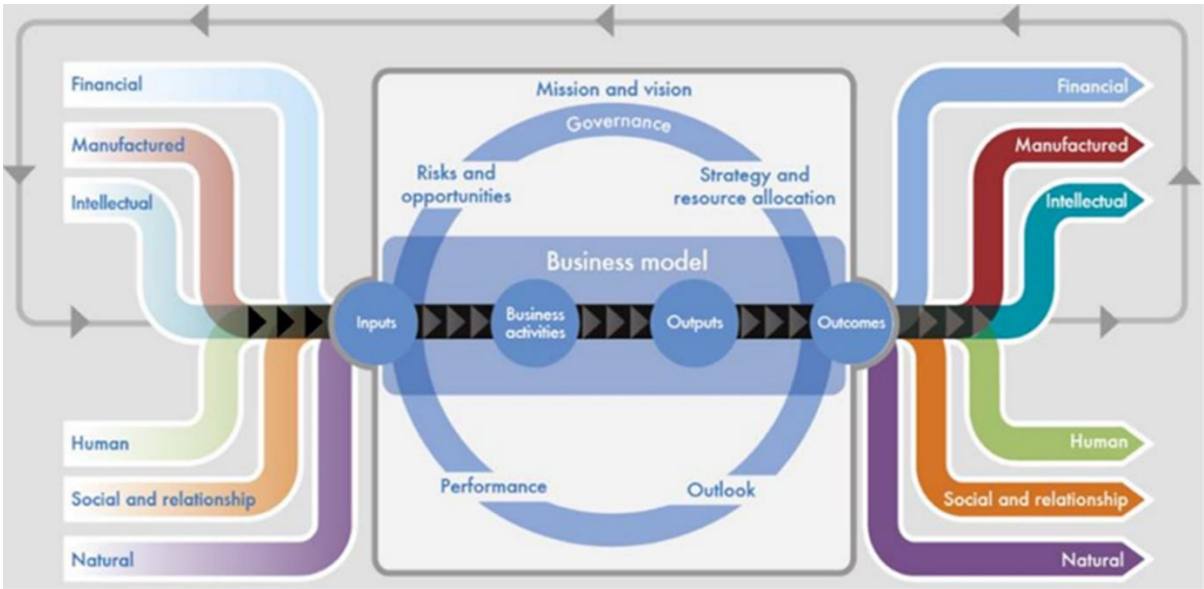
The use of intellectual capital concepts can help LCM in creating strategies that will develop sustainability-related intellectual capital of the people that LCM tries to influence.

Knowledge management allows to capture, to store and to disseminate knowledge. Usually knowledge management solutions are costly systems that capture all available information rendered explicitly to ground truth and rules of thumb. Alternatively, management of intellectual capital focuses only on the knowledge that has business value for the organisation. Intellectual capital implies actionable knowledge and know-how. Its outcomes are less costly and concentrate more on learning than building systems (Dalkir, 2011).

Stewart (1997) defines intellectual capital as organisational knowledge that is used to produce wealth. The best way to preserve valuable knowledge is to identify intellectual assets and to create a management system based on them. Intellectual capital is often visible from the higher market value of an organisation compared to the book value; for organisations with high intellectual capital the difference in value relates to the knowledge and know-how of the organisation and employees (Stewart, 2000).

Intellectual capital is a relatively new topic for academic research. The literature on intellectual capital could be divided into two groups: the first focuses on the valuation of intangible assets. For example, Andriessen (2004) and Wall et al. (2004) provide a broad

analysis of the valuation approaches. King and Roberts (2013) in their guide on the integrated reporting guidelines of the International Integrated Reporting Council (IIRC), listed intellectual capital (Figure 34) as one of three capitals (along with financial and manufacturing capitals) that an organisation possesses to create value.



Financial capital: the available pool of funds, debt, equity or grants.
Manufactured capital: manufactured physical objects that are available by the business.
Intellectual capital: organisational, knowledge-based intangibles, organisational knowledge systems, brands and reputation.
Human capital: people's competencies, capabilities and experience, and their motives to innovate.
Social and relationship capital: the institutions and the relationships within and between communities, stakeholders groups and other networks, and the ability to share information to enhance individual and collective well-being.
Natural capital: renewable and non-renewable environmental resources and processes that provide goods or services that support the past, current or future prosperity of an organisation, including air, water, land, minerals, forests, and biodiversity.

Figure 34. Value creation model and capitals flow (IIRC, 2013).

Intellectual capital is the stock unit of organisational learning while the most precious knowledge in an organisation often cannot be passed on (Bontis, 1999). Intellectual property is not part of the intellectual capital: knowing that an organisation holds a patent is useless if there is no information regarding its potential. Intellectual property is a result of efficient application and development of intellectual capital. The aspects of intellectual property are not related to information and knowledge, they are part of the financial capital of the company, and the individual intellectual capital is part of the human capital that does not belong to the organisation (Roos et al., 1998; Bontis, 1999).

The second body of existing literature on intellectual capital focuses on the conceptualization of intellectual capital and its management. Researchers, including Stewart (1991, 1997), Edvinsson and Malone (1997), Sveiby (1997), Roos J. et al. (1998), Klein (1998); Roos G. et al. (2011) contributed to the development of the concept of intellectual capital by setting the IC

constructs and describing their interactions. This research will focus only on the concept of intellectual capital and its management.

6.3.3.1. IC concept constructs

The existing literature provides slightly differing descriptions of the structure of intellectual capital concepts, but the logic behind is the same as described in Figure 35.

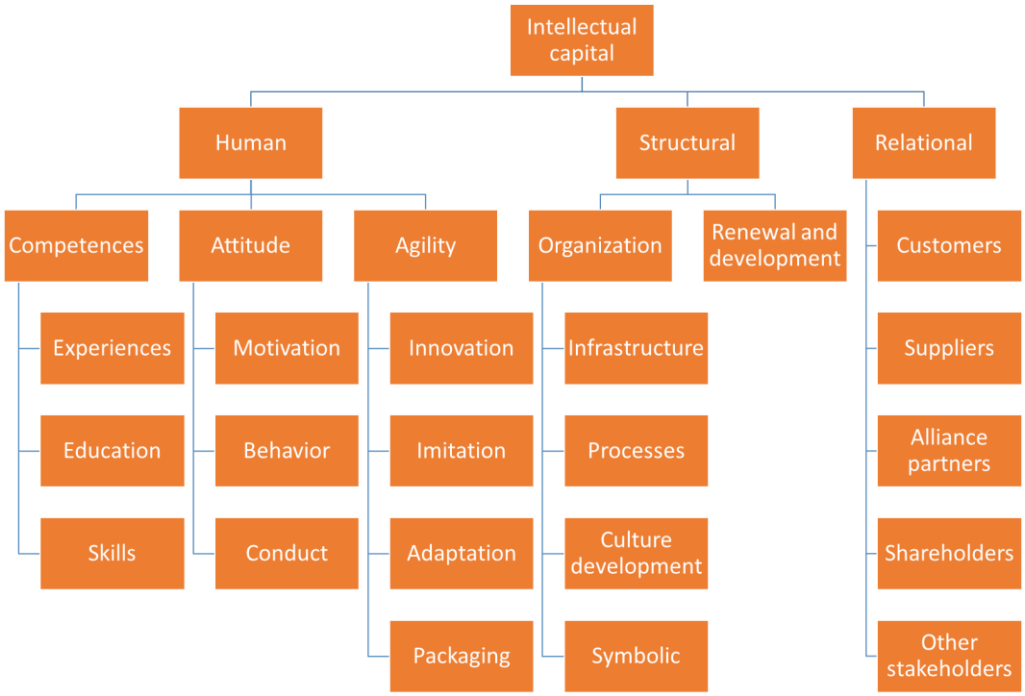


Figure 35. IC constructs (Roos and Roos, 1997; Roos et al., 1998; Bontis, 1999; Roos et al., 2011).

Intellectual capital consists of three main sub-capitals (human, structural and relational) and their constructs.

Human capital is not owned by the company, but this capital is offered by each employee. The alignment of human capital units is a result of the competences, attitude and agility of individuals. The competences are linked with experiences, education and skills of each individual and it is logical that companies need employees capable and willing to use their abilities in the work process.

The attitude implies manners of the employees in the workplace and it consists of their:

- Behavior (for example, enthusiastic people create dynamic environments where everyone is more productive).
- Motivation, their vision and strategic intent towards the task.

- Conductivity implies follow-up actions of an employee involved in a task.

The agility aspect is the ability to transfer knowledge from one context to another:

- Innovation is the ability to build on current knowledge and create new.
- Imitation is the ability to identify innovation from similar contents and to apply it independently.
- Adaptation is the ability to identify innovation from other contexts and to apply it independently.
- Packaging is the ability to turn an idea into a context that makes business sense.

The second construct of intellectual capital is structural capital defined as organisational processes of the business. Structural capital includes all databases, organisational charts, process manuals, and other materials that have relation with information flows. Structural capital relates to the intra-organisational processes and it consists of the organisational and development processes.

The organisation's capital is the effort to turn human capital into proprietary information and to make this information available to all interested parties through the internal networks. It consists of:

- The infrastructure includes hardware and value coming from the structural layout of the organisation (i.e. under different organisational structure types any organisation groups and performs in different ways).
- The processes involve any activity inside the organisation that contributes to the development of organisational capital. Processes could be considered as information flows put together. The target of IC processes development is to have the whole organisation share the learning from each process.
- The culture development is created through constant interaction between the members of the organisation. It can influence the management style and the employees' motivation and continuous encouragement to realise organisational goals.
- Symbolic capital is the ability to develop vision that is powerful enough to be accepted by employees and value chain actors.

Renewal and development capitals contain all the processes that will have impact on the future value, but did not manifest itself yet. Training, research and development, and project development are part of renewal.

Relational capital is the third construct of intellectual capital. Relational capital is defined as knowledge embedded in the relationships outside the organisation, and inter-organisational processes are part of relational capital. Knowledge of up- and down-stream value chains, and other stakeholders is the topic or relational capital. The understanding of needs along the value chain helps a business to assume a leading position.

The IC constructs mentioned above were used by the researcher as starting point on developing sustainability-related intellectual capital (SrIC) conceptual framework that will be described in Chapter 7 and applied to the second case in Chapter 8. These frameworks will help the sustainability strategists and managers in applying the continuous improvement objective of LCM.

6.3.3.2. IC constructs fundamental interactions

According to Kogut and Zander (1992) and Bontis (1999), intellectual capital is a result of its drivers (trust and culture) and development of its sub-capitals (human, structural and relational). In particular, Bontis focused his IC research on describing the interactions that happen at the level of human, structural and relational capitals.

Trust is a very important aspect of intra- and inter-organisational collaboration (Barney and Hansen, 1994). At the intra-organisational level, the individuals and groups should be confident that other parties know their roles (responsibilities, tasks) and know how to deliver the given tasks, and moreover, they (the parties given the task) want and have the competence to do it (Dodgson, 1992). At the inter-organisational level, the aspect of trust is more complicated than at the intra-organisational level. Therefore, in accordance with the objectives of this research, the author will focus on intra-organisational aspects.

Culture is based on values, beliefs and attitudes of the organisation. It is reflected in the language, symbols and behavior of the organisation and is considered as a result of senior management beliefs (Hall, 1992).

Bontis (1999) describes the linkages of each capital (Figures 37, 38 and 39) and his concepts will be used to describe IC constructs interactions. As it was mentioned earlier, human capital is IC that focuses on the intellect of individuals. Bontis (1999) defines human capital as the tacit knowledge of employees.

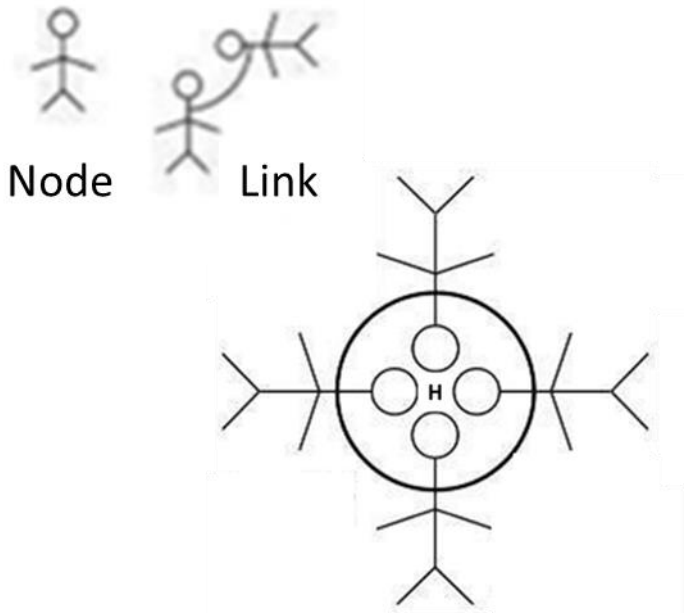


Figure 36. Human capital (Bontis, 1999).

Figure 36 describes human capital at the group level. A node represents the knowledge-work performed, such as decision-making, a process involving innovation, creativity and improvisation or their combination at the individual level (Crossan et al., 1996). This implies that the work is performed through tacit knowledge. Each node has, at least, one link that allows the transfer of certain information. Multiple human capital units are lined up to create a recognizable pattern that makes intellectual capital more readily interpretable (Bontis, 1999).

Structural links transform the human capital into structural capital.

The arrows in Figure 37 show the flow of IC development towards the core of the organisation. The arrows reflect the knowledge embedded in routine or organisational processes.

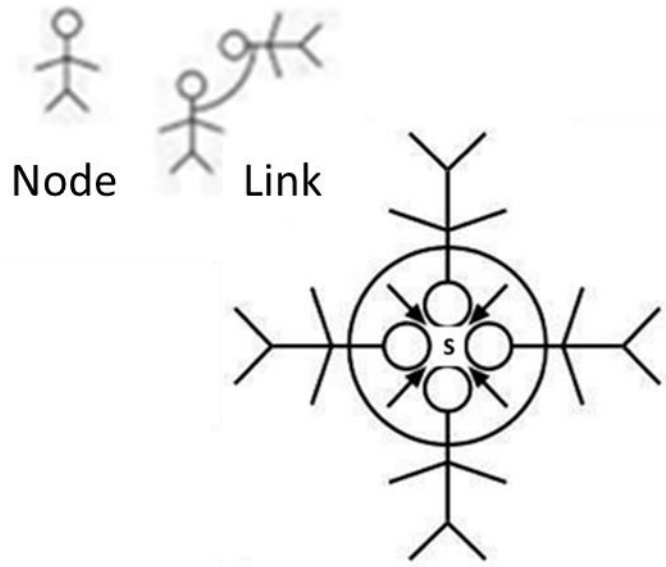


Figure 37. Structural capital (Bontis, 1999).

Links between the nodes represent the information flow between members of the group or organisational groups. The structural capital allows tacit knowledge to transfer into explicit knowledge and into intellectual capital of the organisation. Structural capital allows to capture knowledge by trying, failing or succeeding, learning from the failure or success. It contains elements of efficiency, transaction times, procedural innovation and access to knowledge.

On the relation between human and structural capital Quintas et al. (1997) and Wiig (2000) state that IC has a process and asset knowledge parts, where human capital is the asset, and structural capital is the process.

In Figure 38, the nodes are value chain (VC) actors and other VC stakeholders' information flows. The arrow reflects the external knowledge that should flow to the core or the organisation.

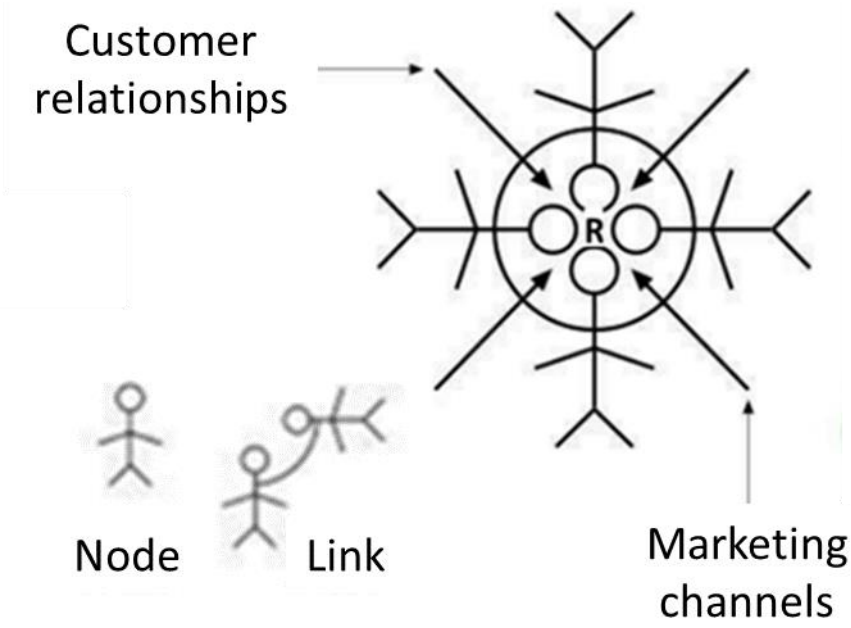


Figure 38. Relational capital (Bontis, 1999).

The relationships are built through spot transactions and long-term exchanges of information and goods.

6.3.4. Knowledge management (KM), intellectual capital (IC) and LCM in the literature

LCM aspect of knowledge management except one case did not receive much attention in academic literature. However, there are two works worth mentioning. For example, Poikkimaki (2006) focused on the SECI of an LCM project at the value chain level. Her study looks at the features of learning and knowledge creation based on Nonaka and Takeuchi's (1995) knowledge spiral (SECI) (Figure 39). Poikkimaki (2006) describes development of explicit knowledge at the inter-organisational level, but she only pays attention to the outcome of the project in regard to relational capital development.

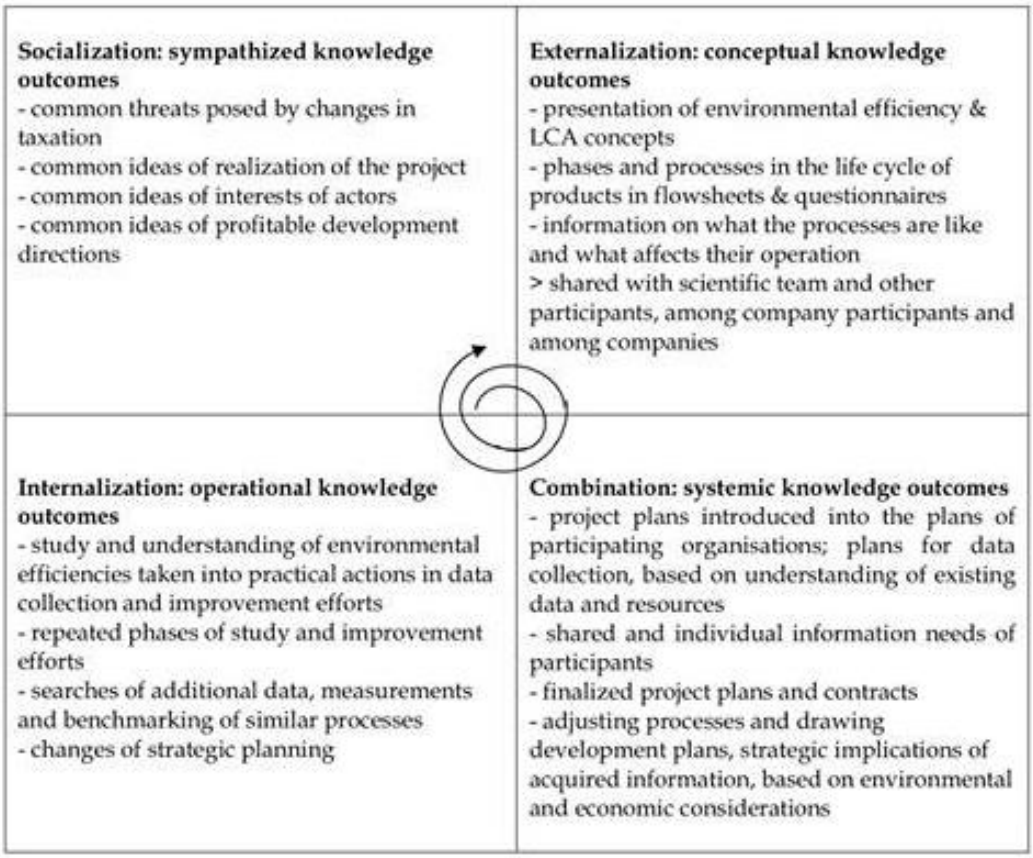


Figure 39. Indications of the four modes of knowledge conversion-SECI in an LCM project (Poikkimaki, 2006).

Nilsson-Linden et al. (2013) conducted a literature review on knowledge management and its role in LCM. The group of authors looked at a dilemma using two knowledge perspectives. From one point of view, a concept of knowledge could be seen as separate from people, and therefore, from tacit knowledge it becomes explicit knowledge. While from other point of view, knowledge is inseparable from individual and situational context. According to Nilsson-Linden et al. (2013), knowledge management systems do not focus on adaptation while providing the appropriate capabilities to develop LCM. However, taking a stance regarding the importance of one of the two approaches while both concepts are unexplored could be a hasty decision.

There are limited studies on IC and corporate sustainability, including Pedrini (2007) on convergences of human capital and sustainability reports, and Mertins and Orth (2012), who proposed intellectual capital as a driver for corporate sustainability development. However, there is no academic literature on intellectual capital and LCM.

6.4. Summary

This literature review aims to clarify the links between knowledge management research and LCM. The author argues for a strong relationship between LCM and knowledge development, as LCM manages new knowledge integration into the organisational processes. However, this link is not well explored in the literature. Therefore, for this study, the researcher considered philosophical constructs of knowledge management and intellectual capital as a starting point for development of LCM concept as any LCM attempt in the literature lacks philosophical grounding. For example, philosophical constructs of knowledge development provided by Nonaka and Takeuchi (1995) and the IC constructs described earlier can be used to analyse the approaches of Poikkimaki (2006) and Nilsson-Linden et al. (2013). Through application of knowledge development philosophical concepts mentioned in 3.3.1.1., the author will demonstrate that knowing in practice refers to individual knowledge and human capital, while knowledge management focuses on the structural capital.

The author considers intellectual capital as a valuable concept that can provide context to the objectives of LCM that influences the integration of sustainability aspects in the organisational processes.

7. Conceptual framework

This chapter uses the knowledge and ideas from the initial case and the KM literature and develops a conceptual framework that will guide the second case with the aim to explore further the knowledge creation process.

7.1. Introduction to conceptual framework development

In the previous chapter the researcher demonstrated that continuous improvement objective was linked to learning and knowledge development. The researcher got to this point by providing a conceptual framework on LCM factors in Chapter 4. Through the initial case described in Chapter 5, the researcher explored the viability of the conceptual framework when it was applied in practice. Moreover, in Chapter 5 the researcher was observing the developing knowledge factor which was reflected in every proposed LCM factor. Chapter 5 also allowed to demonstrate that with the application of LCM, the process of knowledge development should be considered as a link between the LCM objectives and factors. Therefore, in this chapter the research will focus on exploration of the knowledge development in the context of LCM. The researcher will present a research tool that will help to analyse knowledge development and will guide the second case described in Chapter 8.

7.2. The knowing-doing gap in the context of LCM

The knowing-doing gap in the context of LCM is connected to sustainability analysis and integration management objectives. The sustainability analysis objective focuses on the knowing aspect of the sustainability group and the integration management objective targets the transfer of knowledge from the sustainability group to the rest of the organisational groups to influence their actions (doing part). The connection with the continuous improvement exists because sustainability analysis and integration management process happen continuously and after each cycle they improve due to the knowledge gain.

Pfeffer and Sutton (2000) described the phenomenon of the knowing-doing gap. These two authors analysed how multiple companies transformed knowledge into action, and in their studies, they mentioned the so-called ‘performance paradox,' when managers knew how to improve performance, but did not use this knowledge. According to Pfeffer and Sutton (2000),

awareness regarding the existence of a 'knowing-doing' gap does not imply that the gap will be eliminated, since eradication of the gap requires action.

The LCM literature analysed in Chapter 2 discusses the knowing aspect through the lenses of the current and potential sustainability performance. The existing literature on LCM does not focus on the doing aspect: the authors do not explore integration of the information into the organisational processes to promote the doing aspect. The researcher thinks that this makes the implementation of proposed solutions more challenging.

The researcher believes that in the case of LCM the knowing-doing gap might be caused by the difference in business and sustainability perspective. Some of these differences were presented in Table 17 of Chapter 4. Also, Chapter 5 presents an LCM case that repeatedly refers to both knowing (sustainability group side) and doing (rest of groups), yet the literature on sustainable development and knowledge management lacks doing aspect detail while emphasizing knowing. Figure 40 can be used as an illustration to the case in Chapter 5 and to the analysis of LCM literature which demonstrated that the existing approach to LCM is focused on the knowing aspect based on current implementation (marked by color green) and disregards the doing aspect based on the way the organisation makes decisions. Therefore, the existing LCM knowing–doing gap can be explained by underemphasizing of the organisations processes.

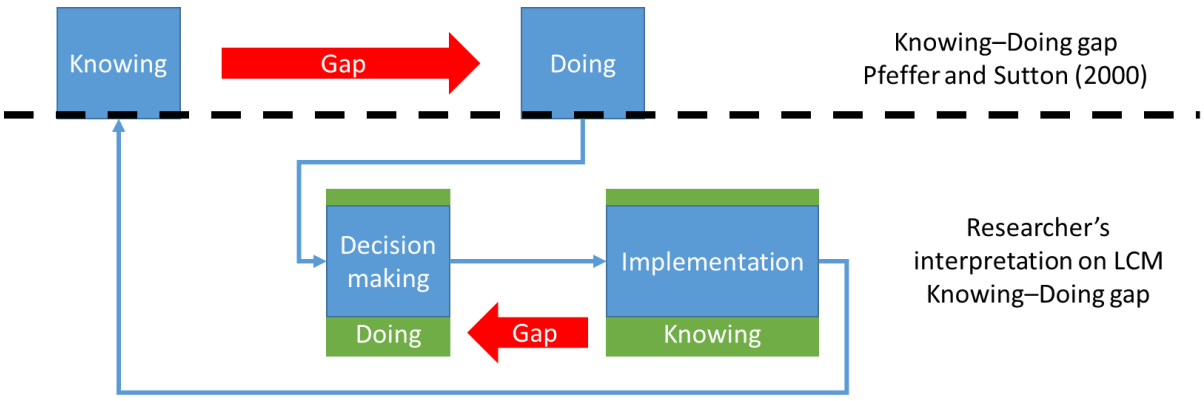


Figure 40. Proposed LCM Knowing-doing gap concept.

'LCM knowing-doing logic gap' proposed by the researcher, can bring additional critical insight into the concept introduced in Figure 40 and potentially improve integration management (objective 2).

A more detailed explanation of the LCM knowing-doing logic gap is provided in Figure 41. It represents information flows when certain decisions are made in an organisation. As it was discussed earlier, sustainability research puts more emphasis on knowing (compared to doing), which does not help the integration of the proposed information. The organisational groups that have to make decisions receive information flows from various organisational groups (marked by grey arrows in Figure 41). Then the decision-making group filters this information in accordance with available knowledge and group priorities (red box), and makes and implements decisions. The knowledge filter in Figure 41 refers to the judgement made by decision-making group. Doing includes organisational processes, as well as ways the information is filtered during decision-making and paths leading to implementation.

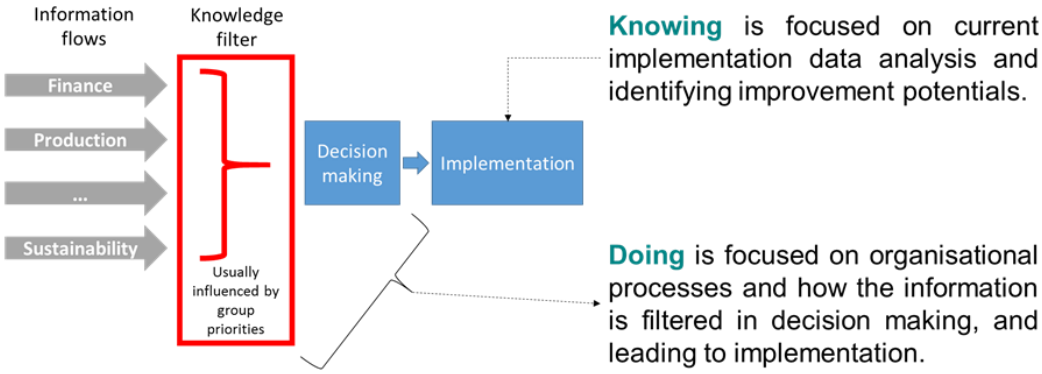


Figure 41. The knowing-doing logic gap.

When applied to LCM, the knowing aspect can be linked to the sustainability analysis objective is directed at provision of the information on the current or potential situation performance. At the same time doing aspect is connected to the integration management objective as it focuses on introduction of the sustainability information infrastructure into the organisational processes. The knowing-doing gap is associated with the continuous improvement objective as it focuses on learning from experience (sustainability analysis and integration management) and enhances LCM processes to improve integration management in the future. This gap implies also learning how other groups process information and make decisions. This conclusion is based on data observation in combination with literature on knowledge management and the logic of the researcher.

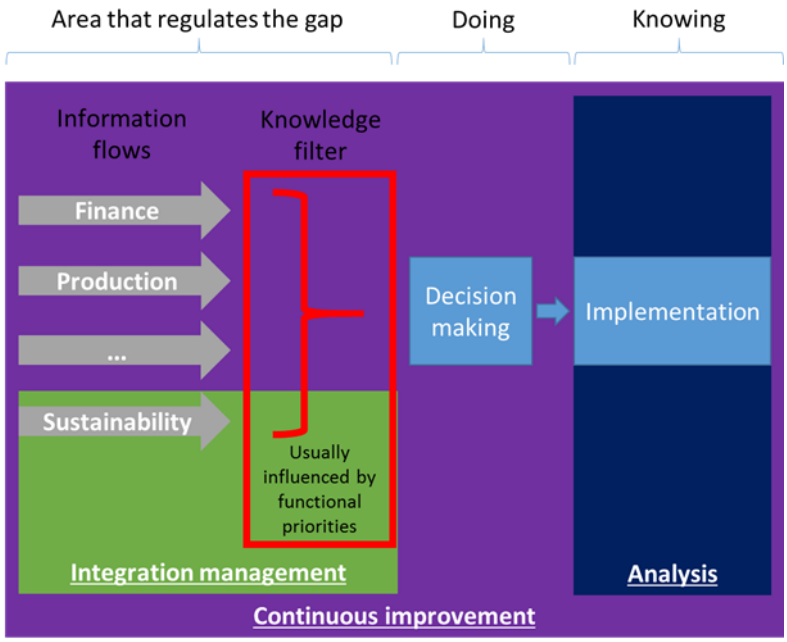


Figure 42. The LCM knowing-doing gap and the link with the LCM objectives.

Based on the previous analysis it can be concluded that continuous improvement objective is very important for the development of sustainability aspects integration in organisation's processes. In Chapter 5, the researcher demonstrated that continuous improvement objective is linked to knowledge development, which is the main focus of this chapter. Knowledge management literature usually refers to knowledge development as a theory that helps in understanding continuous improvement that is rooted in practice. Knowledge development as a theory offers insight into continuous improvement, there are a lot of parallels that come from that.

7.3. Knowledge development and LCM

The review of knowledge management literature in Chapter 6 helped in finding links with the LCM objectives.

- Objective 1 (sustainability analysis) can be better understood through the DIK part of knowledge management construct (DIKA).
- Objective 2 (integration management) and objective 3 (continuous improvement) can be interpreted through the A (knowledge in action) part.
    - Objective 2 can be better comprehended through the SECI knowledge conversion model.

- And objective 3 can be explained through intellectual capital (IC).

The first objective (sustainability analysis) focuses on transforming D-data to K-knowledge and not the DIK concept, as data is collected and analysed to provide information. For example, in the LCM context the researcher developed the info-diversity conceptual framework (Figure 12 of Chapter 4), which enhances the knowledge of the individual(s) who conducted the analysis.

The second objective is integration management. The researcher believes, that knowledge created through LCM sustainability analysis represents a useful input for the integration management objective, as this knowledge has to be transferred to the persons who should consider it before making a decision or taking an action. The raw information represents only partial interest for the decision makers. Usually within an organisation, the sustainability manager is a person who receives this raw information and distributes it to the parties that should be informed, and this process of information flow in the organisation was illustrated through the info-complexity conceptual framework introduced in Chapter 4 and tested in Chapter 5 also.

The sustainability manager could benefit from such a concept since it can continually enhance knowledge integration and influence his integration management actions. To enhance the sustainability performance, the sustainability manager has to make the tacit knowledge (based on sustainability analysis) implicit (that could be integrated into processes) and then explicit knowledge (knowledge of the processes that can be available across the organisation).

The third objective is continuous improvement (CI) and it is linked to intellectual capital (IC). The initial case data showed that each organisational group received information related to their tasks. Taking into consideration sustainability aspects are addressed at the organisational processes level, the implicit knowledge within the organisation could be different for everyone. The data suggests that in the organisational sustainability case the tacit knowledge spreads across different organisational groups and becomes implicit when each group has received the knowledge it is entitled to, and then explicit when the knowledge as a whole spreads around the organisation and becomes accessible to everyone. The CI process within the info-cycle conceptual framework links info-diversity (sustainability analysis) with info-complexity (integration management) because it links data with action.

7.4. The contribution of organisational groups in knowledge development process

The importance of organisational groups along with the implicit knowledge that develops as a result of communication between the sustainability group and the groups it influences is discussed.

In this section the researcher will further explore the relation between constructs of the SECI cycle and integration management (objective 2). While exploring this relationship, the researcher will emphasise that different groups have different information needs, so the groups variability affects integration management.

The researcher considers that SECI is helpful in understanding integration, but it is not sufficient in explaining the integration management objective. The researcher will examine groups effect to study deficiency of SECI. By exploring collected data and making some observation on how SECI explains integration, the researcher will suggest additional points that in combination with SECI will provide a clearer picture.

The data presented in Chapter 5 shows that sustainability organisational group serves as translator of sustainability-related information to all other groups. The sustainability group passes individual bits of information (if possible in the form preferred by receivers) to the groups that need to take action. For instance, this process took place through SAP (in case A). However, this process bootstraps, as certain SECI cycles took place as knowledge was developing from SAP's Stage I and on.

While analysing KM literature, the researcher identified three points that relate to the abovementioned observations and knowledge development aspect of KM.

- Groups importance. The flow of information starts at the individual level in the sustainability group and spreads across various groups. KM literature mentions that each organisational group has different combination of knowledge component factors that are focused on different organisational aspects (Davenport and Prusak, 2000; Pfeffer and Sutton, 2000). Therefore, each group focuses on different knowledge.
- Importance of implicit knowledge. The knowledge spread by the sustainability group is tacit knowledge that becomes explicit by being shared across the organisation.
  The SECI model includes tacit and explicit knowledge and it does not address implicit knowledge that implies taking the action. Instead, the researcher will adopt Eucker's

(2007) model of 'knowledge iceberg,' described in Figure 43. According to Eucker (2007), implicit knowledge can be codified, but it is not yet explicit (Eucker, 2007). Implicit knowledge is the outcome of the knowledge creation process during the time when the individual tries to communicate knowledge. It seems, tacit and explicit knowledge are static states, while implicit knowledge is dynamic.

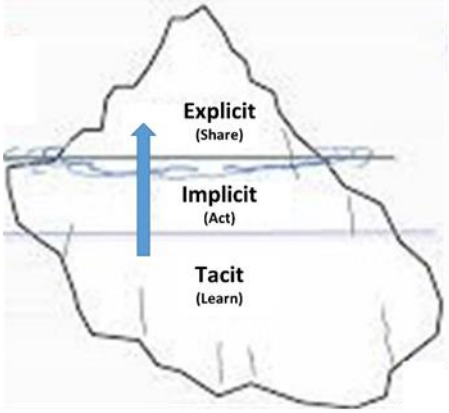


Figure 43. Knowledge iceberg (Eucker, 2007).

- Knowledge development mechanism. Knowledge development is not a single-cycle process, and as case A demonstrated SAP had many cycles (stages). This is linked to the knowledge creation concept introduced by Nonaka and Takeuchi (1995) and described in Figure 33 of Chapter 6. The authors designed this concept to show the transformation of knowledge in organisations. According to this concept, groups of individuals are also part of the process, however, the authors did not develop this idea further. The researcher proposes that if the groups contribution is considered in the process, the spiral suggested by Nonaka and Takeuchi takes a shape of an infinity loop, as described in Figure 44. The foundation of the concept is the choice of the axes, which are the same as in Nonaka and Takeuchi diagram.

In Chapter 2 the researcher showed the existence of a connection between connectionist epistemology and actual domain ontology that concentrates on the events where the mechanism is observed. As this model of the action takes place between explicit and tacit knowledge, the implicit knowledge that develops in-between is the key mechanism of knowledge development. The infinity loop concept is a novel adjustment to the (Figure 33) Nonaka and Taukechi (1995) knowledge creation spiral.

Based on exploratory studies and by integrating Nonaka with later literature, the researcher proposes two major additions to the Nonaka model: first, the inclusion of the intra-group and intra-organisational ontological focus, and then the consideration of the implicit knowledge. The implications of those two changes are captured in a new model (Figure 44) which is presented briefly here and will be the subject of further analysis in Chapter 8.

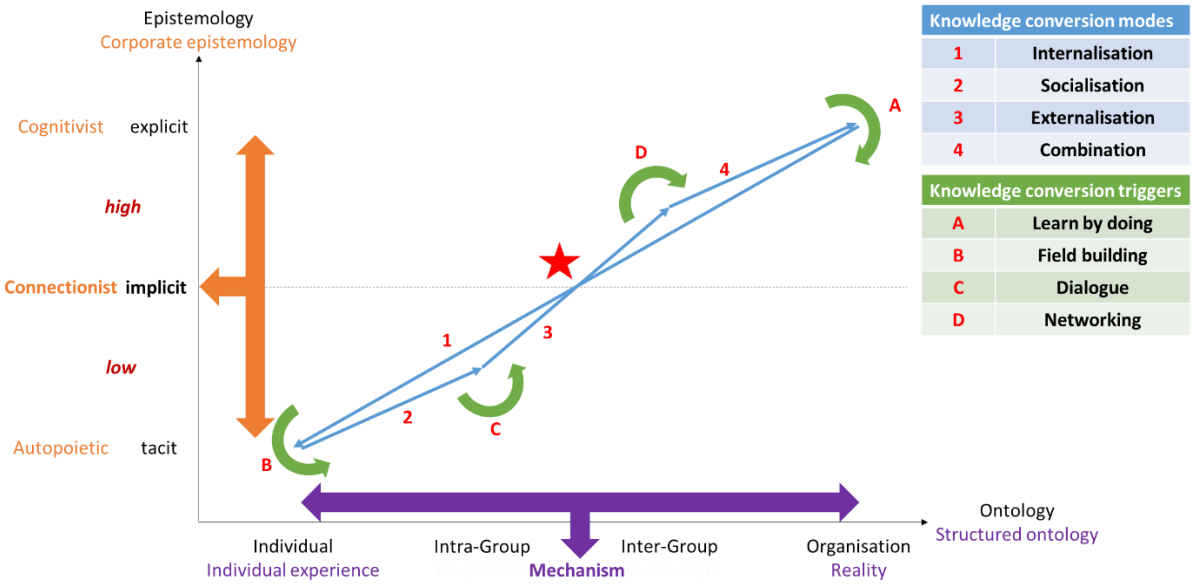


Figure 44. Knowledge development infinity loop.

In this section the researcher has used a well-known framework and brought two additional concepts into that framework based on case A. These additions emphasise the unusual role that sustainability professionals and their group hold within larger organisations' which affects the knowledge creation process. These ideas will be further tested in Chapter 8.

According to the observations and literature discussed earlier in this chapter, the researcher came to the conclusion that:

- The sustainability manager and the sustainability group play a role of gate keepers on sustainability integration for the rest of the organisational groups.
- SECI is also not a single-cycle process, but knowledge bootstraps overtime, and this cyclical process links SECI to objective 3, as the SECI mechanism continuously takes place and the level of knowledge develops.

Therefore, the task of sustainability-related intellectual capital is to describe the factors of the mechanism and the development of implicit knowledge across the various groups, which will be discussed in more detail in the following section.

7.5. Sustainability-related intellectual capital (SrIC) conceptual framework logic

The components and the logic behind the SrIC conceptual framework are introduced here.

The analysis of the initial case and the review of the literature on knowledge management allowed the researcher address continuous improvement (objective 3). As the researcher demonstrated earlier, the continuous improvement objective plays a crucial role in LCM. LCM concept implies application of knowledge in practice (organisational learning) to continually improve the integration of sustainability aspects in the organisational processes and to enhance sustainability performance. However, this aspect was mainly unexplored in the LCM literature, since only Remmen and Thrane (2007) and Jorgensen (2008) stressed the importance of knowledge management as part of the quality management process.

In the previous chapters the researcher has shown that knowledge and knowledge management play an important role in sustainable business management. Using the knowledge management literature, the researcher identified three key challenges of KM that apply to LCM. The researcher followed these steps:

- Analysed the current LCM literature.
- Showed that the problem is elsewhere, not where the LCM literature emphasizes. Using the initial case as an example, the researcher demonstrated that doing a higher quality LCA does not resolve all issues, and through the case he discovered the cause of the problem.
- Analysed the initial case emphasizing the importance of knowledge transfer in comparison to the raw quality of knowledge provided by LCA.
- Then the researcher addressed the literature again to understand the place of knowledge transfer (mainly through KM).
- Based on logic and the LCM literature analysis, the researcher provided a framework to bring new concepts into the LCM conceptual framework.
- The researcher proposed to use intellectual capital as a base for corporate LCM.

- Moreover, the researcher proposed to emphasise the utility of continuous improvement objective.

In the next sections, the researcher will look at LCM practice through the lenses of IC, using the concepts of strategy, tactical and operational levels. This section describes the lens that the researcher used in the case described in Chapter 8. The next section analyses the levels of strategy, tactics and operations, and proposes one way to bring them into the LCM framework.

To understand the difficulty of learning in a complex sustainability environment, the researcher will use literature on LCM practice and data from the initial case. Key influences on learning performance are sought and these are then used to improve the authors model of LCM.

The LCM conceptual framework addresses the objective of continuous improvement. LCM implies the application of knowledge in practice (organisational learning) to continually improve the integration of sustainability aspects in the organisational processes and to enhance sustainability performance.

7.5.1. From LCM to SrIC

Intellectual capital refers to the way the information and knowledge are utilised by the organisation to achieve certain results (Roos et al., 1998). The concept of intellectual capital can be used as a base of LCM concept learning factor and continuous improvement objective. These two aspects did not receive enough attention in earlier research. However, these two concepts should play more important role because they allow to focus on establishing and continual improvement of the integration of sustainability aspects in the organisation.

For this research that is focused on integration of sustainability aspects, the researcher would like to propose a new term ‘sustainability-related intellectual capital’ (SrIC) that will be used to refer to the knowledge on sustainability and the ways organisation and its groups use this knowledge.

7.5.2. SrIC conceptual framework logic

To develop a SrIC conceptual framework the researcher will connect strategic management, knowledge management, and intellectual capital concepts. The SrIC conceptual framework can be used by the sustainability manager to identify areas that will enhance the strategy and intellectual capital in integration of sustainability aspects into organisational processes.

To explain the suggested conceptual framework, the author will use an example of the initial case that was earlier discussed in Chapter 5. The main task of the initial case was to address the organisational processes level gap by adopting an LCM approach. The text in Table 27 illustrates the actions of the organisation at every strategic management level. The remainder of section 7.5.2. discusses each part of Table 27 in more detail.

At the strategy level the organisation wanted to be ready for the launch of Higg score and the management was interested in receiving a competitive score. At the organisational processes level, the SG had to develop the integration method. Finally, at the operational level, the tactics of organisational processes level were put into effect, and the success of the tactic was possible to measure through the performance improvement. Moreover, the text in purple provides more information on the data grounding of the proposed SrIC conceptual framework.

The SrIC conceptual framework described in Table 27, was inspired by the intellectual capital levels of Dalkir (2011). These core concepts were applied as lenses to the data collected in the initial case. As described in Table 27, the strategic capabilities correspond to the business perspective, the tactical competencies to management perspective, and the operational technologies to hands-on perspective.

As it was mentioned earlier three strategic management levels (adapted from Labuschagne and Brente, 2005) are applied in parallel with three IC levels (adapted from Dalkir, 2011). The main capability addressed in this model is leadership. The researcher treats leadership as an essential capability that allows to influence and to manage people implementing a strategy. The leadership capability relates to the ‘gap’ reduction aspect of the ‘knowing-doing’ gap.

The tactics level consists of three categories, including structural, information and groups tactics. The case described in Chapter 5 showed that all participants positioned themselves with the organisational group) that they belonged to, which makes the researcher believe

that the group characteristics should be considered as an important aspect of SrIC tactics development.

The last level is the assessment of the current IC in action within the organisation. This level consists of two categories, the human capital and cultural capital. Both human and cultural capital influence individuals and assessment will help to identify the areas where IC assets need further improvement. At the same time inconsistencies between capabilities level and tactics level will show IC development processes that require further improvement. The human capital provides information on IC nodes and the cultural capital present information on links among the nodes.

It should be also noted that suggested conceptual framework does not address the relational capital as the focus of this research was on the intra-organisational processes.

The assessment of the SrIC has three levels. The first relates to the analysis of the IC in action, which implies an understanding of the current situation. The second level is the capabilities and tactics match that addresses parts of the 'knowing-doing gaps'. The combination between capabilities and tactics is essential as it connects tactics with the purpose and tracks the tactics performance. The last level is the intervention proposals, which is based on the two previous levels since opportunities for improvement allow to identify where interventions are required. The first level is focused on knowing the current situation, the second level helps to identify opportunities for improving knowing and doing, and the last level proposes ways to improve 'knowing-doing gaps'.

Table 27. Strategic management, knowledge management, intellectual capital and the relation with SrIC.

Intellectual capital (Dalkir, 2011)		SrIC				
Levels	Focus	Levels	Focus	Factors	Aspects	SAP case grounding
Strategic	**Capabilities:** Strategic skills necessary to integrate and to apply competencies. Capabilities imply individual's knowledge ('know how' at an individual level; e.g. sustainability manager) that under the right conditions can be aggregated to form company's competency. Capabilities are core competencies that can be realised through sound knowledge management practices.	**Capabilities:** strategic skills necessary to integrate and to apply tactics to achieve targets	Leadership (Kouzes and Posner, 2012)	Model the way	Clarify and affirm shared values	During the follow-up interviews, it became apparent that values on sustainability were not clarified as there was no clear process. The action alignment was observed only on the sustainability aspects when a target was set.
					Align action with values	
				Inspire a shared vision	Envision the future	It became evident that there was no shared vision for the future of sustainability.
					Enlist others in a common vision	
				Challenge the process	Looking for opportunities	Through SAP, the SG tried to challenge the existing organisational process by proposing a platform and seasonal cycles that helped to achieve small gains in the area of fabrics sustainability.
					Generate small wins and learn from experience	
				Enable other to act	Build trust and facilitate relations (collaboration)	The SG manager tried to enable others to act by seeking to avoid the eliminating factors of Higg index, by trying to offer alternatives and by making reasonable suggestions from both sustainability and business points of view. Moreover, the SG manager initiated SAP to enhance the competencies of the employees and their ability to act.
					Develop competences	
				Encourage the heart	Showing appreciation for individual excellence	During the interviews data on appreciating or celebrating achievements was not gathered since there was no evidence at that time. However, some months later the company received a sustainability achievement award that raised publicity of the organisation and from further interaction with the SG, it was evident that the company appreciated their efforts and celebrated this victory.
					Celebrate values and victories, community spirit	
Tactical	**Competencies:** Necessary tactical skills that allow to achieve high performance ('know how' at the organisational level)	**Tactics** actions or strategies planned to achieve a certain level of performance.	Structural	Infrastructure	The value is coming from the structural layout of the organisation.	The organisational structure changed from divisional to strategic business units. This change improved the flow of information across the same functions of different branches. For example, interviewee (A) stated: *'Basically, with globalisation, the work changed because we have to develop a lot of new processes …in order to accommodate the need and to find the way to work with each other. It was the information flow that had to change obviously. I think the major impact was the fact that we had to come up with new processes while carrying on the normal tasks, like developing the product.'*
				Process	Series of actions to achieve results.	The process mapping and the idea of the platform and seasonal cycles in Chapter 5 showed that the processes flow can be more efficient.
				Renewal	All the processes that have been created to have impact on future value (e.g. training, organisational learning processes, repeated processes that increase knowledge)	SAP on its own could be considered as a project that will continue having an impact in the future.
			Information	Information systems	The way the information flows in the organisation.	The company has a newsletter on sustainability that does not run smoothly and is not an efficient way of communicating. Interviewee Ro mentioned: *'We have a newsletter that we communicate, but it is no one's main task, so when something is behind, it is the first thing that stays behind. We need to set up a process, a wiki or something on sustainability. [The newsletter] is not enough, even it is not a process.'*
				Collective knowledge	Mechanisms of providing explicit knowledge. This can relate to factors using knowledge in action, such as 'Ground truth', 'rules of thumb'.	An SG person (Interviewee B) mentioned the lack of collective knowledge and that in many cases the rule of thumb is the only way of sharing knowledge: *'Rule of thumb is still the basis of a lot of what we are doing. There is a lot of work going on at the moment on improvement of systems, upgrading, because it is really necessary. So until now, because of the poor systems, it was hard to effectively integrate some of the sustainably considerations into the process. So it is all in people's heads, in documents, it is not clear.'*
				Measures	Data/ information available on specific aspects to support decision-making.	Table 20 in Chapter 5 on the LCA data collection illustrates that there were limited measurements available. Moreover, the incident with the non-accurate data of the material bill (section 5.3.2.1.1.).

			Organisational groups	Focus of action	Action taken at each organisational level and its analysis in 4Ps (people, product, production, place), VC and TBL coverage.	Table 25 of Chapter 5 shows the variability of action at the level of the apparel team and serves as an illustration of the different focus on groups (section 5.3.2.2.2.).
				Motivation	Engagement of employees with business strategies.	All group members stressed importance of moral aspects. However, business objectives prevailed, as interviewees mentioned costing and making quality products as important factors for their decision-making. The latter illustrates motivation aspects of the group tactics. For example, respondent M states, that *'Most important is cost reduction. And then … it is function, technical aspects. And then … it is sustainability.'* While respondent A said*: 'I would say that for us, definitely functionality and quality stays in the first place. I would put, performance, quality. Sustainability …we have this in mind too. But the first two is the performance and quality of a product.'*
				Conductivity	The activity and follow up of employees after being conducted to take certain action.	In Chapter 5 it was mentioned, that as long as there was a formal target and management drove it; conductivity is fine, if not the action varies. If it was mentioned as a formal target they were working on it. If it was not a formal target the conductivity was related to the priorities.
				Agility	Ability to transfer knowledge from one context to another, see common factor in two distinct pieces of information and link them, and improve both knowledge and output through innovation and adaptation.	There is also lots of knowledge adaptation from SAC and academic institutions.
Operational	**Technologies:** Methods and tools that allow to produce physical results. In this case, technologies imply the link with the management practices as mentioned in subchapter 1.1	**IC in action:** Current status of individual intellectual capital and interactions between individuals.	Human capital	Knowledge in action	Knowledge and decisions usually reside in peoples' mind. Here the focus is on some factors that characterise the knowledge of individuals in organisations. The factors include experience, judgement, intuition, complexity, missed knowledge, values, and beliefs.	The absence of knowledge was the main reason for conducting the initial study. For example, interviewee (D) mentioned: '*the result was a highly technical and quantitative report that we could not touch for a long time because we could not understand it, we did not have the knowledge and experience on how to use this information.*
				Competences	Skills, education, training, talents, and know-how of individual.	Only SG people had some specialized knowledge of sustainability issues. Personnel of the apparel team received sustainability-related training before SAP, and their knowledge of sustainability aspects could be considered as very limited. For example, interviewee (Ma) mentioned*: 'I am struggling with sustainability, I have not studied it.'* To the question of the interviewer *'Can you please describe the sustainability-related project, like the project you did with us and training that you had that is related to sustainability?',* interviewee M said**:** *No, I did not have any, only the one with you.* This indicated the limited training on sustainability issues on persons from other groups.
			Cultural capital	Symbolic	A mix of recognition and history used to influence the perception and sense making of actors inside and outside the organisation.	Several respondents mentioned that different 3Ps levels relate to different TBL levels, and this can explain the difference of action drivers for environmental and social related aspects. For example, interviewee B stated**:** *'On product the focus is on environmental and on supply chain process … it is social.'*
				Interrelations	Alignment of goals and incentives with the strategy at all organisational levels. Sharing of knowledge and staff assets with strategic potential.	The apparel team manager had to show to her executive that she takes action on sustainability, as mentioned in Chapter 5. Also, analysis section of Chapter 5 discussed strong interrelations between the members of the apparel team, but SG had close working relationship (a process) only with the sourcing team.

7.5.2.1. SrIC capabilities factors

As mentioned earlier, leadership is the main capability, while sustainability is an add-on aspect in groups processes and decision-making. The sustainability strategist or the manager has a key responsibility to integrate the sustainability aspects to lead the various levels and functions of the organisation. Linnanen et al. (1995) (Figure 57) and Crews (2010) have proposed their own sustainability leadership concepts, which have many similarities with Kouzes and Posner (2012).

However, the researcher's perception of leadership was borrowed from Kouzes and Posner (2012), a well-known and widely used five practices of exemplary leadership model developed in 1987 by Kouzes and Posner. The first row of Table 27 describes five capabilities and two related factors that lead a group or an organisation in achieving certain targets. These capabilities are strategic skills that help to integrate and to apply tactics and competencies to lead a group in achieving certain targets. The application of five leadership capabilities suggested by Kouzes and Posner to the initial case helps to identify several leadership issues. This gives the researcher some confidence in the explanatory power of this choice of leadership framing.

7.5.2.2. SrIC tactics factors

The middle row of Table 27 includes tactics that relate to the management competencies directed at enhancing SrIC and related factors. Table 27 describes three tactic groups and related factors. The case provided strong evidence that tactics (actual actions and their logic) were strongly influenced by:

- the organisational structure,
- the way in which information was shared (or not), and
- whether group or individual knowledge was used on the issue at hand.

The structural component refers to the way the organisation is functioning and the way processes help in delivering the sustainability strategy. The information tactics refer to information systems, knowledge applications, and information infrastructure to support the application of the sustainability strategy. These structural and information tactics are directed at creating explicit knowledge and helping people without specialised knowledge to deliver results. The

structural and information tactics categories were influenced by the distinction that Wiig (2000) made on knowledge process and assets; the structural tactics refer to knowledge processes while information tactics to knowledge assets. The group tactics is a mix of competencies that can help in mapping and improving the functionality on the sustainability of different groups. The group tactics were inspired by the different needs and priorities of the various organisational groups explored in the initial case.

The researcher proposes to assess the utility of the LCM conceptual framework by studying leadership capabilities across all three of these influences. In this section earlier mentioned influences are considered in the context of literature to show there is an explanation of their existence but there is no literature to support the importance of these three factors in explaining overall performance.

7.5.2.3. Sustainability-related intellectual capital in action factors (SrIC-in action)

'Intellectual capital (IC) in action' is a current condition of sustainability-related intellectual capital. IC in action is addressed in the last row of Table 27, however, it contains some variations of the IC concept introduced in Figure 35 which are explained by the researcher's view on SrIC. Moreover, the researcher introduced the cultural capital level to internalise the trust and culture drivers as stated by Bontis (1999) and discussed by the researcher in Chapter 6. The initial case allows to re-consider these factors. In Chapter 8, the researcher will provide several examples that relate to the factors mentioned in Table 27.

7.5.3. SrIC assessment process

The structure and logic of the SrIC conceptual framework were explained in the previous parts of the section. This section presents how the researcher can conduct useful observations of IC in LCM practice, in order to better understand the utility of IC in improving LCM practice and the ways of applying the concept of IC in LCM practice to improve the latter. Using an example of a case, the researcher conducted a four-step analysis that introduced application of intellectual capital thinking in LCM. The purpose was to observe:

1. Whether the use of IC concepts improved LCM,

2. In what ways LCM changes when influenced by IC concepts, and
3. What are strengths and weaknesses of IC concepts and their particular implementation.

Below the researcher explains how the tool is used in practice. As described in Figure 45, the assessment process has four steps.

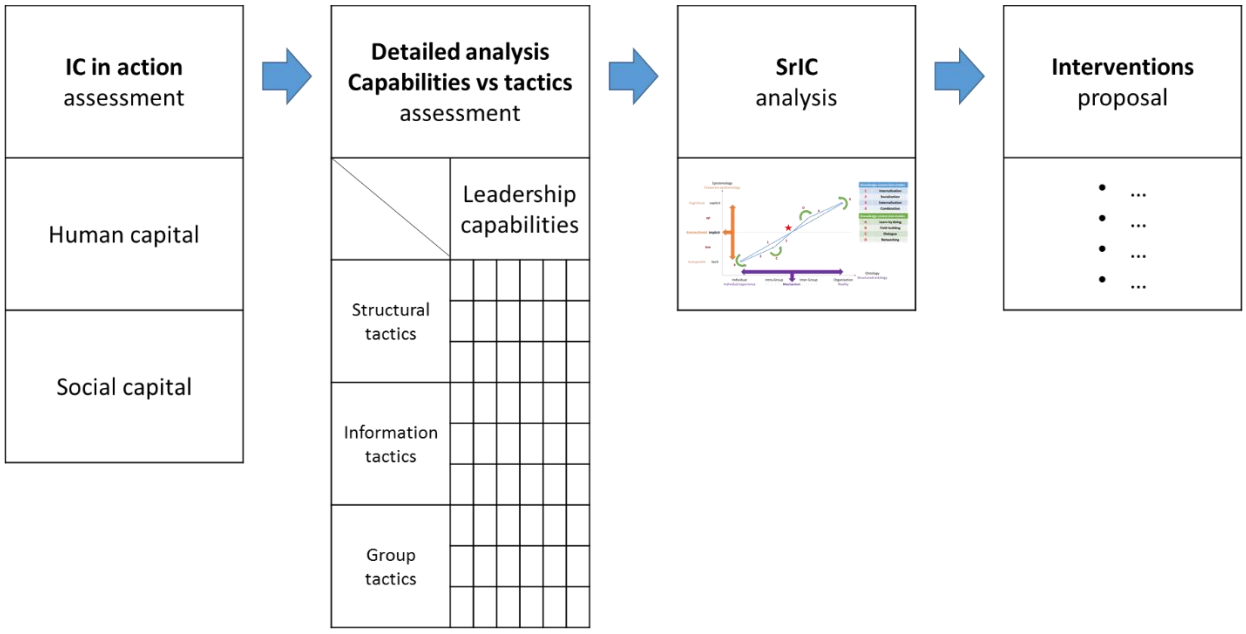


Figure 45. SrIC assessment steps.

The first step of the process involves the assessment of the intellectual capital in action through collection of data on human and cultural capital factors. The human capital factors focus on the tacit knowledge aspect and the cultural factors relate to the explicit knowledge aspect. As a result, the assessment helps to understand the status of intellectual capital, its strength, and weaknesses at the individual and organisational levels.

During the second step (capabilities vs. tactics assessment), specific data is collected on the capabilities and tactics. The detailed analysis focuses on the leadership and tactics used in the development of implicit knowledge from tacit towards explicit knowledge, and understanding of factors that improve or impair performance with variable groups. The information is inserted into the detailed analysis table, and the relation between capabilities and tactics provides a structured understanding of the performance of the groups.

The SrIC analysis comes after the assessment steps. The information from the previous steps is analysed taking into consideration the infinity loop knowledge creation mechanism. The tacit knowledge part relates to the human capital, the explicit knowledge is connected to the cultural capital, and the implicit knowledge is tied with the detailed analysis table. Through this process, the importance of collected information is assessed, and the links between different matrix slots are established. This process helps to identify the main bottlenecks in knowledge transformation. Figure 46 provides a more detailed description of the process, where according to the performance each slot is specified by a different color.

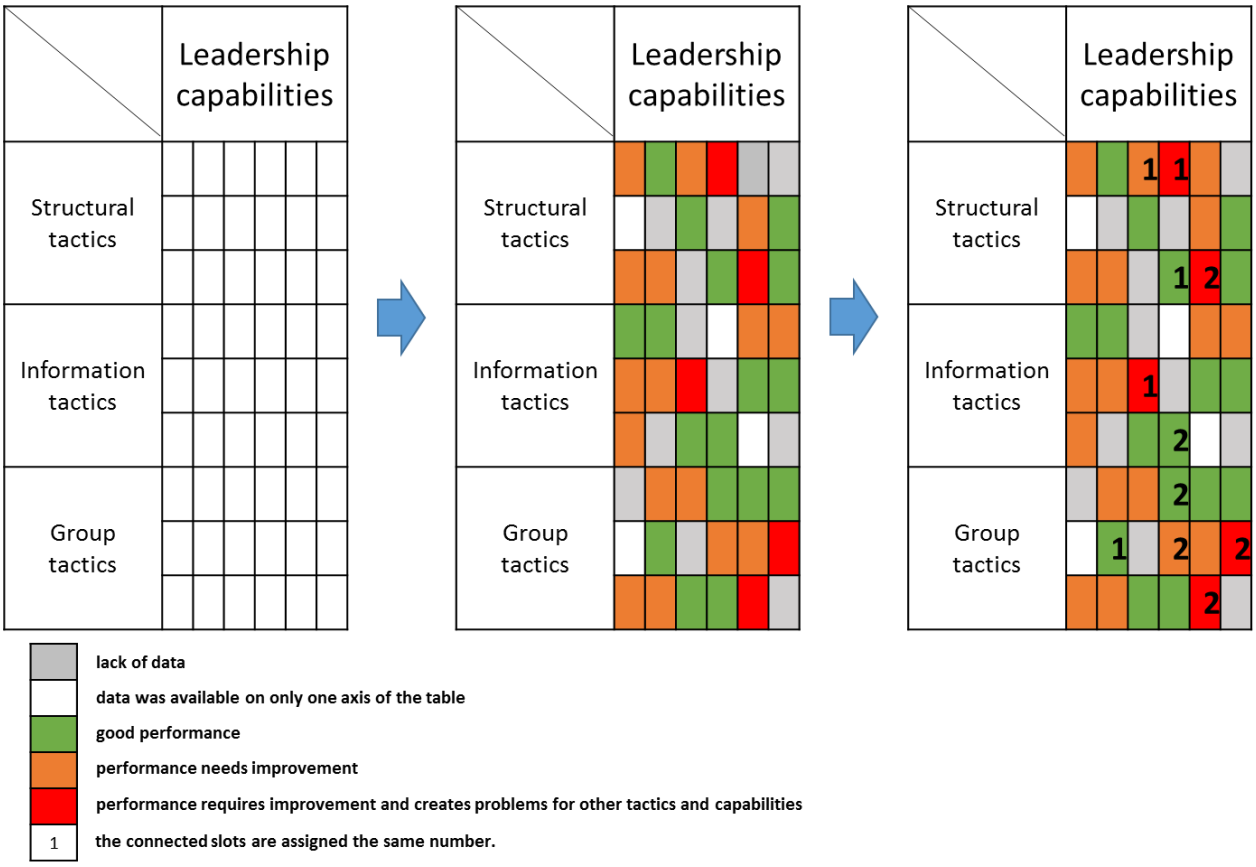


Figure 46. Detailed analysis steps.

The proposed three step assessment process will be used in the second case described in Chapter 8.

7.5.3.1. Detailed analysis factors

To illustrate the link between capabilities and tactics the researcher will introduce a two-dimensional model. The researcher believes this connection between tactics and capabilities is essential in:

- connecting tactics with purpose and understanding the level of performance;
- assessing 'doing' component, and
- assessing the gap in-between.

To identify weak aspects of each tactic and to identify opportunities for improvement it is important to see how each tactic performs under different purpose.

The leadership capabilities guide process development and each step builds on the previous, whereas tactics are individual IC constructs.

Table 28 provides detailed analysis of capabilities vs. tactics assessment. The table has one hundred slots; there are three black colored slots because the three related leadership factors are renewal tactics, and they do not fit with the process tactics. Each slot represents a specific link between leadership capabilities and tactics. For example, the slot marked by a red colored star shows influence of the organisational infrastructure in clarifying shared values.

Table 28. Detailed analysis (capabilities vs. tactics).

Capabilities	Leadership (Posner and Kouze, 2012)	1. Model the way		2. Inspire a shared vision		3. Challenge the process		4. Enable others to act		5. Encourage the heart	
		Clarify & affirm shared values	Align action with values	Envision the future	Enlist others in the common vision	Looking for opportunities	Generate small wins and learn from experience	Build trust and facilitate relations (collaboration)	Develop competences	Showing appreciation for individual excellence	Celebrate values and victories, create spirit of community
Structural tactics	Infrastructure	★									
	Process										
	Renewal										
Information tactics	Information systems										
	Collective knowledge										
	Measures										
Groups tactics	Focus										
	Motivation										
	Conductivity										
	Agility										

7.6. Summary

In this chapter, the researcher described the 'knowing-doing' gap concept and its place in the LCM context, as well as the role of various groups in knowledge creation, and the transformation of tacit knowledge into explicit. Based on the intellectual capital concept, the researcher developed the SrIC conceptual framework to enhance the continuous improvement objective of LCM.

Through this study of a complex phenomenon the researcher at times had to invent precise language, this was the case for the specific use of knowledge management also. Below are the knowledge management related terms used and the purpose within this study.

Table 29. Knowledge management related terms use in this study.

Term	Refers to	Purpose
Knowledge transfer (and knowledge conversion)	The transfer of sustainability knowledge from SG to the rest of the organisation. The researcher also refers to knowledge transfer as knowledge conversion when referring to the conversion of tacit knowledge to explicit.	Knowledge transfer is ultimate key goal of SG.
Knowledge development (and learning process)	The new knowledge captured through the application of LCM/sustainability actions.	Better understand.
Organisational learning	The process of capturing knowledge to form collective knowledge.	Better shared understanding.
Knowledge management	A systematic approach that allows to capture, to structure and to disseminate knowledge through the organisation	Effective use of knowledge assets.

The researcher followed an innovative approach to develop the SrIC conceptual framework. To explain IC concepts, the researcher adopted a model based on knowledge creation spiral of Nonaka and Takeuchi (1995), which is focused on the analysis of individual and organisational levels, but does not take into consideration the importance of different organisational groups. To account for the role of organisational groups, the researcher suggested an infinity loop based on the knowledge creation mechanism. In this chapter, the researcher discussed his ideas on knowledge development aspect of LCM with the aim to test them in Chapter 8.

8. Company B case: analysis of the knowledge creation process

This chapter explores the potential of the SrIC conceptual framework to enhance the integration of sustainability in the organisational processes of an organisation. The researcher uses the steps described below to conduct this part of the research:

- Explore the organisational structure of the case company and develop a research plan with the case partner.
- Identify through this case how SrIC might advance LCM and knowledge capital.
- Assess the role of integration management in this case company.
- Use the lens of the continuous improvement objective to analyse the knowledge capital of the case company.

8.1. Introduction to the case

A Fortune 500 multinational manufacturing corporation with more than twenty years' of experience in sustainability announced a list of sustainability targets to be achieved in the next ten years. However, during the first two years, the progress was not satisfactory.

The researcher met the member of the staff responsible for sustainability research and sustainability strategy at the corporate level (case partner) during an LCM conference and decided to initiate an action research LCM case to explore the potential of SrIC in the company. The project lasted from November 2013 to October 2015.

The aim of the case was:

- To explore the potential of intellectual capital (IC) in assisting the integration of sustainability aspects into organisational processes through the SrIC conceptual framework introduced in Chapter 7.
- To assist the company's sustainability group (SG) by providing guidance and possibly developing a conceptual framework that would help the company to improve these issues and to enhance the implementation of the corporate sustainability strategy.

To achieve the aim three successive targets had to be fulfilled:

- To investigate group sustainability targets implementation in practice, e.g. the team wanted to understand how targets help decision-making process and what real improvements these targets bring at the level of the local business units.
- To provide input and feedback to sustainability group to make the targets implementation process more efficient, effective and business relevant.
- To receive feedback from participants regarding conceptual framework provided by the researcher and to incorporate these results into the conceptual framework.

From here on the case company will be called company B, and the case will be called case B.

8.2. Case method

In this section, the researcher will provide an outline of the research approach.

The study of this case had several steps. Firstly, the researcher tried to analyse the organisational structure and the organisational levels of company B. The aim was to understand how the company was structured. This knowledge helped the researcher to make a decision regarding the case coverage during the second step and to understand the organisational processes and information flows during the main data collection.

8.2.1. The organisational structure, levels and sustainability-related processes

Company B is a large and complex organisation, it is present in more than 150 countries, it employs more than 150 thousand people, and it has many different business units that offer thousands of products to the customers around the world.

To have a good understanding of the organisation the researcher analysed the available documents and asked specific questions to the case partner. Cognitive mapping was used to represent the researcher's interpretation of the organisational structure and levels. Moreover, the researcher asked many of the participants to comment and approve the maps.

The top part of Figure 47 describes the researcher's interpretation of the organisational matrix for company B. The blue colour illustrates the executive committee while orange shows the divisions, red indicates the business units, with yellow reflecting the geographical structure (regions and countries), and with green marking the corporate groups and the local groups.

Company B has a complex organisational structure, that could be described as three-dimensional. The organisational matrix (top part of Figure 47) describes the horizontal interrelations between three constructs, divisions, geographical regions and corporate groups of the organisation. The divisional structure (marked in orange and red) is the key part of the organisation because at this level the company designs, produces and sells the products. The geographical regions and the corporate groups play a supportive role: the geographical structure controls the regional performance, and the corporate groups provide guidance and assist the implementation of strategies.

The bottom part of Figure 47 describes another dimension, the organisational levels. Each part of the organisational structure is described vertically (and could be read only vertically), for each part different organisational levels are described. It is interesting that the geographical structure controls divisions and corporate groups performance in each country, and therefore, it does not expand below the business units' level. Another important aspect is the interdependence of the corporate groups organisational levels with two other structural parts. The country managers of each corporate group relate to the geographical structure, while the lower levels relate to the divisional structure at the same time.

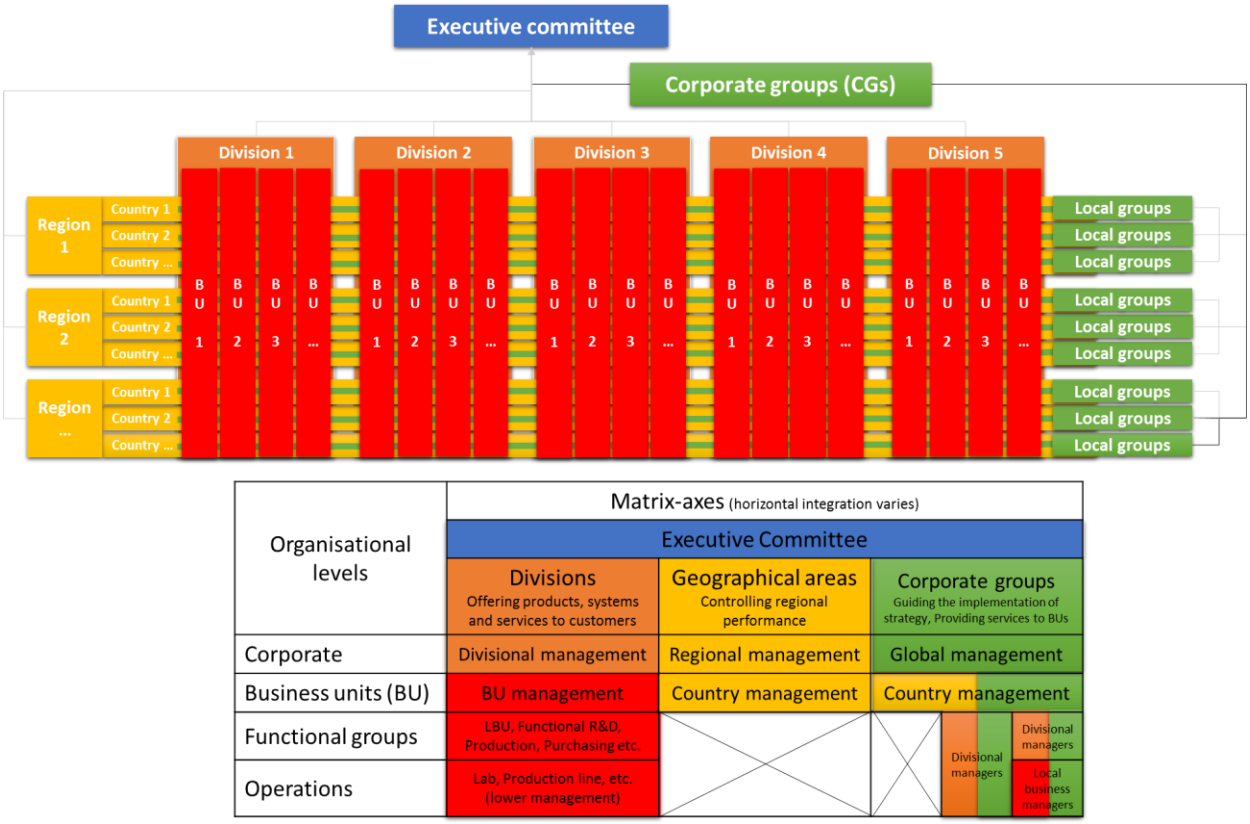


Figure 47. Corporate organisational structure and structure of organisational levels.

The researcher explored the conformity between sustainability-related processes and the organisational structure and levels. The data collection was conducted through document analysis, interviews and focus groups.

Based on the analysis of the collected data, the process is taking place at three organisational levels (strategic, organisational processes and operations) as described in Figure 1. The Global Management Sustainability Group (GMSG) develops the group sustainability strategy at the strategy level, Country Management Sustainability Group (CMSG) guides the decision-making at the organisational processes level, and the Local Division Sustainability Managers (LDSM) and Local Sustainability Manager (LSM) influence and assess the implementation at the operations level. The specific steps at each level are described in the Appendix 9.

This first stream of data collection allowed the researcher to understand how the organisation operates, to share his perception with the research partner and participants, and to receive feedback from the participants to ask more detailed and specific questions. In addition, data

collection helped to explore the LCM practice of the sustainability group (SG) of company B, as well as knowledge development and continuous improvement aspects.

8.2.2. Case coverage

Due to the time and resource constraints the case coverage was focused on the most advanced country from a SG and performance point of view. This particular focus allowed the research to build upon learned lessons and best practices that could be applied to other countries.

The coverage of the case was limited to the organisational structure and organisational levels highlighted in Figure 48. The areas coloured in light grey were not covered by this case. The areas that maintained their colour were not fully covered, but the researcher interviewed experienced personnel who worked in this area.

For the interviews and focus groups, the case partner contacted different people who had a formal sustainability-related task or interacted with people from the SG in the chosen country both in the divisional structure and corporate groups structure. The aim was to have a group of at least ten people who played various roles in the company.

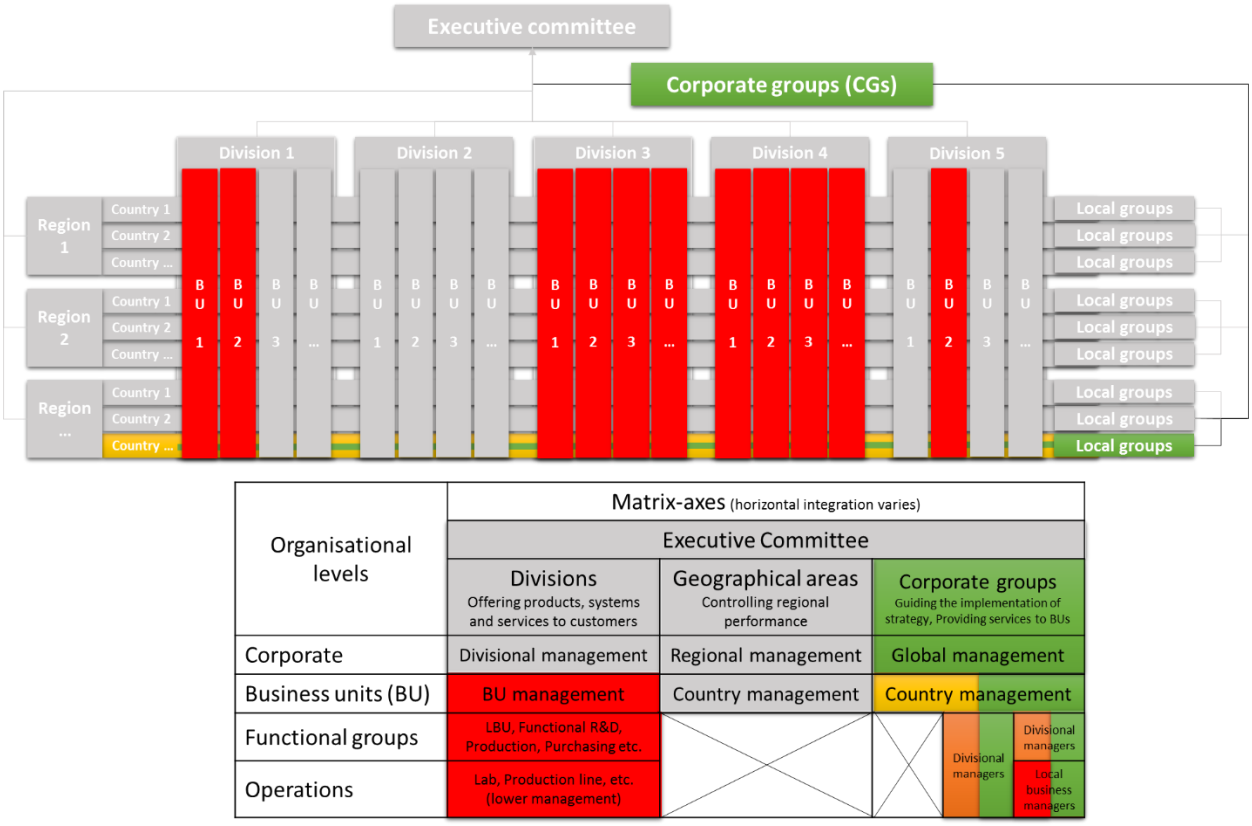
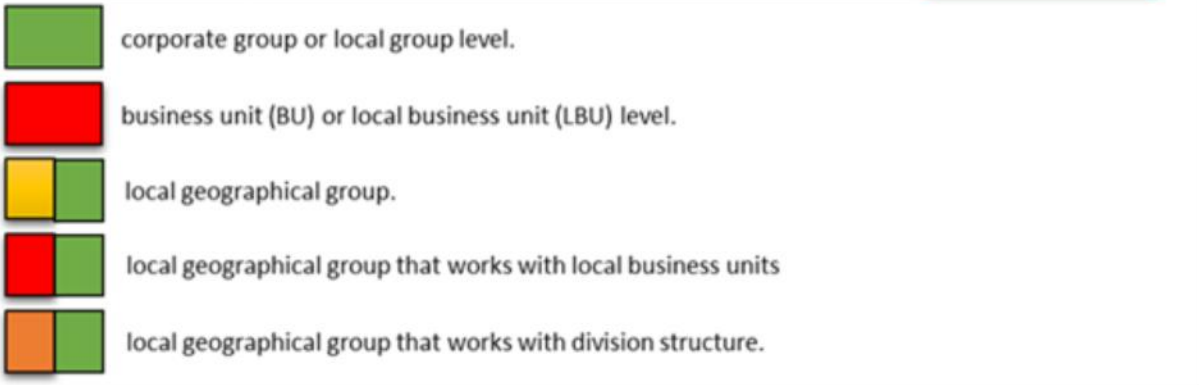


Figure 48. Case coverage.

The case involved fifteen persons (Table 30) who participated through seven interviews, four group interviews and two focus groups (Figure 49) conducted in April and October 2014.

Table 30. Participants list.

Roles				Participants
SG	GMSG (Global Management Sustainability Group)			2
	Country network	CMSG (Country Management Sustainability Group)		2
		LDSM (Local Division Sustainability Manager)		1
		LSM (Local Sustainability Managers)	LBUSM (Local Business Unit Sustainability Manager)	2
			LGSM (Local Group Sustainability Manager)	2
non-SG	Other Corporate Groups (CG)	CG Project Manager		1
		LG Manager		1
		LG Division Manager		1
	Division	BU/LBU Manager		1
		Line Manager		2



The group of participants was diverse as the SG representation covered all the levels of the sustainability group (Table 30), including the two persons responsible for the sustainability strategy for the whole company and the two members of the team responsible for sustainability management in the chosen country. Six more participants from other parts of the organisation who also joined this study had sustainability component as part of their work and interacted with SG.

8.2.3. Data collection process

The case was conducted within a period of two years. During this case, the case partner and the researcher had variable meetings and phone calls to set up the case and discuss the progress. The data collection had two streams: the first was solely focused on the intra-SG group interactions and the findings of the first stream lead the researcher to the second stream that included the intra-organisational SG interactions.

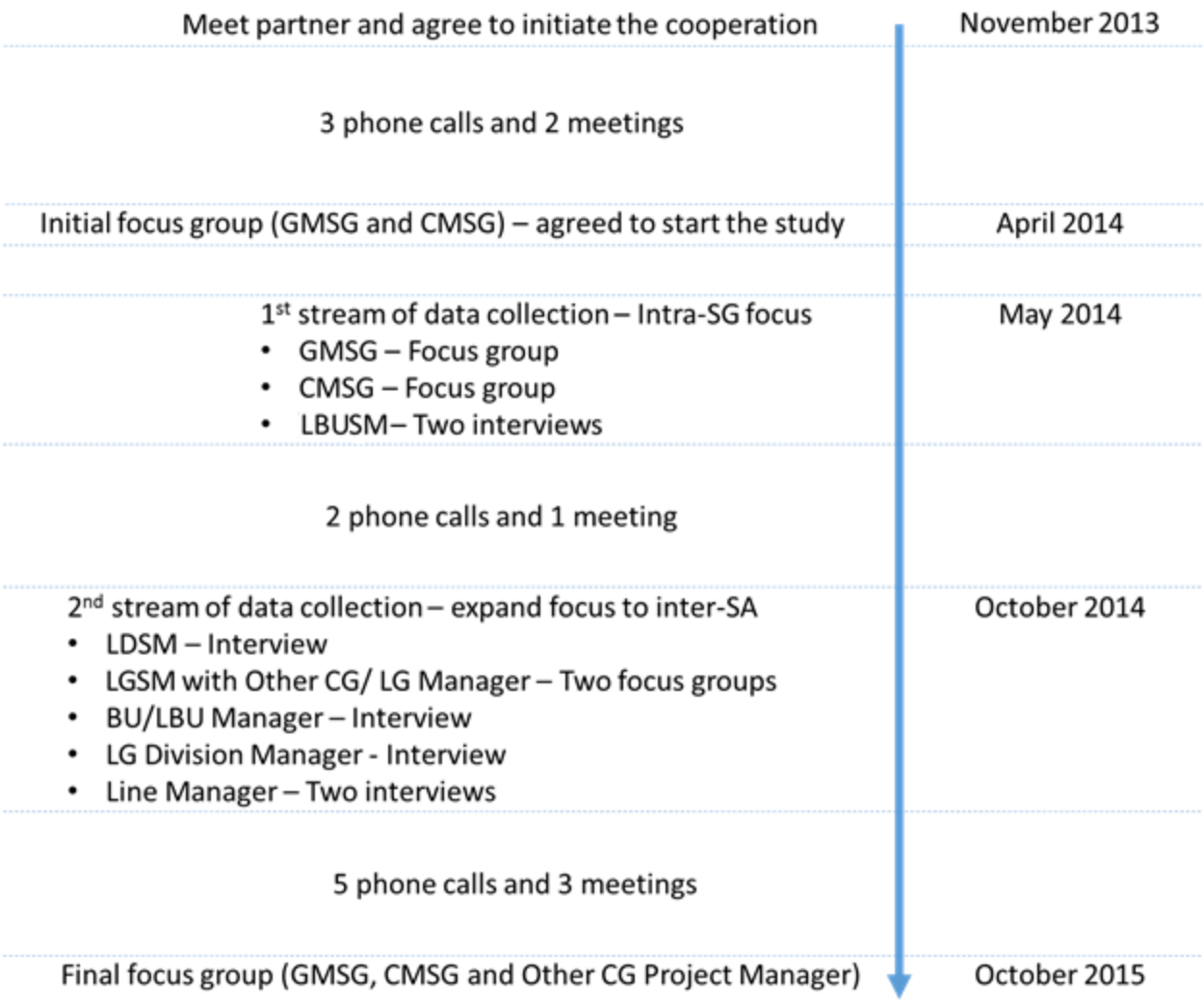


Figure 49. Timeline.

The researcher conducted several semi-structured interviews and group interviews with participants and they lasted from seventy minutes to four hours. All interviews and group interviews (except the first and last focus groups) started with questions on the sustainability-

related process (how it took place, what worked well and what not, and what could be improved). These were the starting points while the rest of the questions depended on themes brought by individual participants.

The open culture of the company allowed to have group interviews and focus groups as it was very common to discuss problems and to help in finding solutions. That was the reason why whenever it was possible to have more than one person in the room during the data collection, it was decided to use this option. This gave the opportunity to participants with the same or different role to share their views and the other partner to comment on them to advance the data collection.

The initial focus group was focused on identifying the need for this case, whereas the final focus group was devoted to discussing and approving the findings of the case.

8.2.4. Data analysis

The data collection and analysis were focused on the continuous improvement objective (objective 3) and SrIC management in company B. As it was earlier addressed in section 7.1, the continuous improvement objective contains the sustainability analysis and integration management (objectives 1 and 2). Consequently, this case touched upon all three objectives while the main focus was on the third objective.

The data analysis process is described in Figure 50. First, the interviews were transcribed. Then the quotes of the transcriptions related to a specific type of IC (human, cultural, structural, information, and groups) were moved to a new document focusing on each capital. After that, the 'capital' documents were further analysed in accordance with the individual capital factors, and each quote was codified to help with further analysis. Then the interrelations among factors of the same and different capitals were identified. After that, the researcher analysed the capitals related to the SrIC-in action, and draw parallels between capabilities and factors related to structural, information and group tactics information.

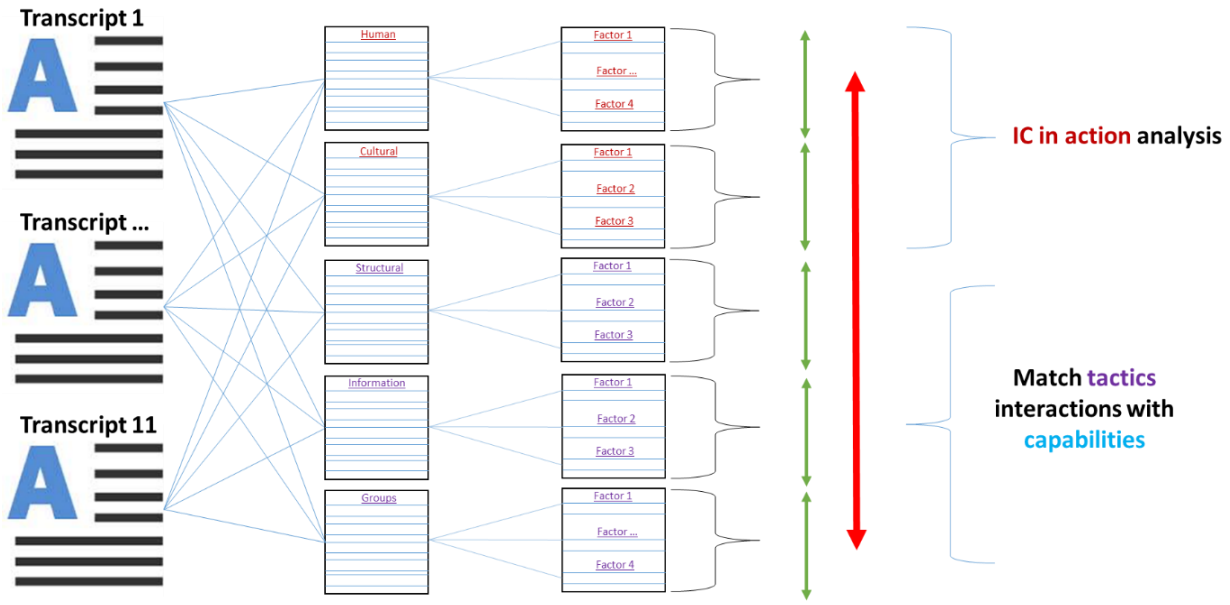


Figure 50. Data analysis process.

The identified matches were linked to the related table slots. Each slot was coloured according to the performance. Table 28 aims to identify specific factors of implicit knowledge development process; the Table's structure can provide three different ways of analysis:

- Focus on capabilities: the Table should be read vertically. Then it allows to identify the tactics that need improvement in the development of a capability factor.
- Focus on tactics: the Table should be read horizontally since it allows to identify the capabilities that lead to tactic lags.
- Connect various slots that relate to each other because they explain the condition of SrIC-in action hotspots or other points of interest.

The analysis of this section will focus on the third way of analysis mainly pointing to the SrIC-in action hotspots identified. According to the analysis, these points can have the largest influence on the enhancement of SrIC performance and are mentioned in Table 46 as hotspots.

8.3. SrIC analysis of company B

The analysis consists of three parts. The first part focuses on the current status of individuals and their interaction IC. The second concentrates on sustainability's group tactical strategies to achieve certain results. The third discusses the feedback of company B.

This study was conducted to test the researcher's ideas mentioned in Chapter 7. The SrIC can help with analysis of some of the hotspots that create the knowing-doing gap. Moreover, the SrIC provides directions on how to improve leadership and to develop better tactics. The conceptual framework of SrIC allowed exploring the way the tacit knowledge of GMSG (sustainability targets) became explicit across company B.

As it was earlier addressed in Chapter 7, SrIC has two main analysis legs: the first is the SrIC-in action that is a static view of the current IC-in action, and the second is the SrIC-detailed analysis that focuses on the factors that have the dynamic to influence the SrIC-in action. The data collected for case B were filtered through the lenses of these two steps of SrIC analysis.

The limited literature on sustainability-related intellectual capital does not analyse organisations. While single case observations cannot be generalised, nevertheless, it is argued here that the observations made are entirely new to the literature. Due to the length limitations of this thesis, the researcher would not be able to provide the full list of data, but to discuss the most representative and interesting results.

8.3.1. SrIC-in action analysis

The analysis of the participants' sustainability-related human and cultural capital showed that the capital of the sustainability group requires further enhancement.

The SrIC-in action refers to the status of sustainability-related intellectual capital of individuals and the interactions between individuals in the organisation. The researcher introduced the conceptual framework of the sustainability-related intellectual capital in action in Chapter 7 (7.5.2. and 7.5.3) based on data observation influenced by the IC literature. The SrIC-in action comprised of the sustainability-related human and cultural capitals is described in Table 31 and is further explored in this chapter.

Table 31. SrIC-in action factors.

	Factors	Aspects
SrHC Human capital	Competences	Skills, education, training, talents and know-how of individual.
	Knowledge in action	Knowledge and decisions usually reside in peoples' mind. Here the focus is on some factors that characterise the knowledge of individuals in organisations. The factors are experience, judgement, intuition, complexity, missed knowledge, values and beliefs.
SrCC Cultural capital	Symbolic	A mix of recognition and history, used to influence the perception and sense making of actors inside and outside the organisation.
	Interrelations	Alignment of goals and incentives with the strategy at all organisational levels. Sharing of knowledge and staff assets with strategic potential.

8.3.1.1. Sustainability-related human capital (SrHC) analysis

In this section the author studies various levels of management across global/national/local parts of the organisational structure and searches for evidence of ability to successfully use sustainability understanding. The researcher identified ten levels in the hierarchy of the organisation (see participants list in Table 30), five of which were sustainability-oriented roles, and the rest were operational roles important for implementation of sustainability projects. To analyse the individuals' ability to use sustainability data, the author chose the human capital framework (described in Chapter 6) as a widely-used tool for such type of analysis. For example, Roos et al. (2011) referred to the competences factors and Davenport and Prusak (2000) used the knowledge in action factors in the cases they analysed.

The sustainability-related human capital contains two factors, the sustainability competences and the knowledge in action are described below in more detail.

8.3.1.1.1. Competences

During the interviews, the researcher asked the participants questions related to their sustainability competences (education, training and years of experience). The provided answers were codified and inserted in the related column of Table 32 that offers a summary of the SrHC aspects for the different groups of participants.

Moreover, the answers of some of the participants included additional information on the condition of the SrHC aspects that further characterised the aspects. For example, these are some typical quotes regarding the competences of the LSMs.

LBUSM-1 stated: *'I don't know anything about the legislation, about the [country] law and I think that training is a big problem...',* and an LGSM-1 mentioned: *'I had no training at all for this role.'*

Both SG country managers expressed their concern regarding the quality of training and knowledge of sustainability, which at the divisional level is much better compared to the local level. For instance, SG country manager B stated:

'LSMs training is not the best. We have some regular training. Every year we have some fundamental environmental introduction, one day. And then we occasionally [provide training on] fundamental environmental legislation and auditing, ISO 14001. We have had a week-long training for doing auditing for several of these people as well. But it is very much learning on the job I would say.'

From the data described in the competences column of Table 32 and the participants quotes, including the ones mentioned above, the researcher concluded that despite playing a critical role in the organisation, the LSMs had very limited years of experience and competences in sustainability.

8.3.1.1.2. Knowledge in action

During the interviews the researcher asked questions related to the aspects of individual knowledge in action. The four aspects (experience, judgement, ability to deal with operational complexity and seeking missed knowledge) were explored individually. The researcher asked questions related to each aspect and the obtained data were codified and inserted in the related column of Table 32.

Experience

The researcher asked all the participants how they obtained knowledge on sustainability (experience). Their answer was used as raw data, which were codified to be inserted in Table 32. Every interviewee talked about obtaining knowledge through 'learning by doing.' For example, representative of LDSM mentioned that 'learning by doing' takes place in company B:

'if you come as a person with no environmental background and don't have any [previous experience] …much learning on the job I would say. … We are trying to facilitate through experience.'

Also, Interviewee LBUSM-2 who has sustainability-related education mentioned:

'Most knowledge here came from practice. The university training helped, but I learned more here through practice …'.

Judgement

Obtaining data regarding judgement is not a straight-forward process. The researcher asked all the participants about issues they considered important and issues that required improvement in sustainability at their area of influence. Through the data analysis, the researcher distinguished two types of answers about the importance: the first was related to sustainability performance (codified as 'a1'), and the second answer was related to the benefits of focusing on sustainability (codified as 'a2'). The replies regarding improvement did not vary. If the respondent addressed the issue of importance and mentioned improvement for the (local) strategy, the reply was also codified as 'b'.

Below there are two comments from respondents who focused mostly on answering question about importance. For example, a GMSG respondent who was answering question codified as 'a1', stated:

*'You can't point every problem everyone wants to face, so then we have hundreds of problems, so that is a problem [to find] balance. Completeness would keep the balance and not point out one specific area. So [it is necessary to] find the right balance. '*The BU/LBU Manager who was addressing question codified as 'a2', mentioned: *'You have to weight the pros and cons. If the product is 10% more efficient, does is it worth the effort? If it is 20%, yes, it is worth it, but 10% and [it requires] this amount of money... You know, [you have] to take a business decision on.'*

There are also two comments from members of the staff who addressed both aspects. A CMSG respondent, who was addressing both questions 'a1' and 'b' mentioned:

'We have decided this year, if we are just supposed to do one thing within the environmental field, [we will] focus on the environmental audits so we can get this done for once and do it well.'

Moreover, an LG Division manager, addressing questions 'a2' stated:

'More or less the environmental and the economic goes hand in hand here.'

while discussing the area that required improvement he mentioned question 'b'**:**

'We could integrate a CO2 calculator to our current tool.'

Ability to deal with operational complexity

The researcher discussed the adoption of the sustainability targets in their area of interest with the individuals and based on their replies, the researcher interpreted if their knowledge was detached or attached. The terminology used here rests on Davenport and Prusak (2000) who developed the concept of knowledge in action.

For example, respondent working at GMSG mentioned:

'For everyone, everything is not relevant. If you are [an] R&D person, maybe integrity is not the first thing you talk about, but if you are a project person sent to Russia, for example, maybe you would think it is important. Same with SG persons. If you talk to an SGA person about a manufacturing issue, they won't have detailed knowledge of the process because it is not their role to know about it. It is about guiding and helping to implement sustainability processes on your role context. It is not expected to know [all] the details.'

An LSM from local business unit mentioned that they need help from the Real Estate LGSM-1,

'We don't own all our houses, we need to cooperate with the owners because the rent that we have, we pay for the house, we pay for the electricity, etc. So, the real estate and real estate LSM needs to help with that complexity and processes.'

Below is the quote from the interview with line manager regarding understanding of complexity by non-SG members of the staff:

'The LSM had the target to decrease our scrap rate to 2%, by now we have 10%. I can say at rubber production at the moment with all the problems we have, 4% is ok. And then we can [try] to go better, but in the beginning the target should not be 2% and then we discussed other possibilities [how to get] there and it is not achievable for us right now. It was hard to make her understand it, because she thinks only [about] the targets and not [about] the process.'

Based on data received, the researcher noticed that SG and non-SG members had different views on complexity. SG group members do not usually participate in the processes since their major role is to support the development and implementation of sustainability targets. This does not apply to LGSMs because they focus only on the sustainability aspects of the LG that they work for, and the tasks are aligned with their experience, while LBUSMs focus on the whole umbrella of sustainability aspects of the LBU.

On the other hand, the non-SG people have an attached understanding of complexity. Specialists have the knowledge of complexity while SG people usually lack it, which sometimes is reflected in setting unrealistic targets.

Another thing that was also revealed during the interviews was that sometimes LSMs have attached view due to their previous experience, for example, because of a role that was attached to the processes. The researcher thinks that this previous experience plays an important role and should be shared with other LSMs who lack this experience and require this knowledge.

Seeking knowledge

Last but not least, the researcher asked the participants where they seek for knowledge to fulfil the sustainability targets when they miss the knowledge to work on the targets. Knowledge could be obtained internally and externally.

On many occasions LSMs mentioned that they struggle to find knowledge and support:

LGSM-1 *'When I started it was really hard to find help. Now I know a person here, that knows. But how can I find the people that know? It is a problem.'*

LBUSM-1 *'It is a very big problem I think. So lots of my time goes to seeing people. I had to ask. It is a problem. Now I know who I should ask if I had a question about it.'*

LBUSM-2 *'The energy saving projects that we need to do. How do we do it? The energy analysis that we are supposed to do? We don't know what it should look like. We don't know who to ask to help us with this.'*

The interview with an LG division manager was also revealing because he mentioned that he is not asking for information.

LG Division manager *'That is a relative question because I'm not asking a lot for this information from the LSM.*

Based on interviews with LSMs, it was possible to observe that, the knowledge transfer happens internally: even when respondents seemed aware about some sources of external support, they perceived them as potential resources.

8.3.1.1.3. SrHC summary

Table 32 contains all the codified data on SrHC mentioned above. After the completion of the table the researcher identified areas of weakness (for example, where the relative amount of experience is low compared to the group that is being influenced by the individual). Those areas with noticeable difference in performance are highlighted in red. The red areas show weakness and trends.

The researcher observed that LSMs have limited sustainability competences and at the same time according to the organisational structure and the participants' comments, the LSMs hold a key role in influencing the rest of the organisational groups to adopt the sustainability targets. Furthermore, the analysis of four 'knowledge in action' factors showed that SG and non-SG members of the staff obtained knowledge in a similar way (learning by doing), but their performance (judgement and ability to deal with complexity) was different, therefore, the personnel had different view of the process.

Table 32. Sustainability-related Human capital (SrHC).

Roles			Competencies			Knowledge in action					
			Sustainability education	Sustainability training	Years of experience	Experience	Judgement	Operational complexity		Seeking missed knowledge	
							Focus on a, b	Detached	Attached	Internally	Externally
SG	GMSG		X (0/2)	√	25-15	Learning by doing	a1	√	X	SG global network, high level management	Consultants, academic institutions
	Country network	CMSG	√ (2/2; post-graduate)	√	10-15	Learning by doing	a1 & b	√	X	SG country network, other LGFs and LBUs that might have the information	-
		LDSG	X (0/1)	√	5	Learning by doing	a1 & b	√	X		Limited Auditors, consultants, suppliers, online information
		LBUSM	½ (bachelor)	√ (weak)	0.5-2	Learning by doing	a1 & b	√	X		
		LGSM	X (0/2)	½ (weak)	0.3-1	Learning by doing	a1 & b	X	√	SG country network	
Non-SG	Other CGs	CG Project Manager	√ (1/1; post-graduate)	√	~10	Learning by doing	a1 & b	X	√	-	-
		LG Manager	X (0/1)	X	-	Learning by doing	a2 & b	X	√	SG country network	-
		LG Division Manager	X (0/1)	√	-	Learning by doing	a2 & b	X	√	SG country network, own GF	Suppliers
	Divisions	BU/LBU Manager	X (0/1)	√	-	Learning by doing	a2	X	√	SG country network	-
		Line Manager	X (0/2)	√	15 (1/2; ISO 14001)	Learning by doing	a2 & b	X	√	SG country network, own LBU	-

X: absence of the factor
√: presence of the factor

The notes in the parenthesis provide information on the presence of the factor.
The numbers in the 'Years of experience' column do not refer to a range, but the years of experience of each of the two participants.

The researcher thinks that the difference in understanding of sustainability between SG and non-SG persons undermined interaction between SG and the rest of groups, but on the top of that, the LSMs who were in charge of most of the interactions with the other groups, had very weak human capital. Consequently, the main SrHC issue identified is the weak performance of LSMs who cannot help in leading sustainability tasks with other organisational groups.

8.3.1.2. Sustainability-related cultural capital (SrCC) analysis

The sustainability-related cultural capital contains two factors, the symbolic capital and the interrelations (Table 31). Roos et al. (2011) refers to both of these factors in their cases. The participants' answers provided the raw data and the researcher observed some trends among the answers. The identified trends from each aspect are described below.

8.3.1.2.1. Symbolic capital

During the interviews, the researcher had an opportunity to explore two aspects of symbolic capital: (1) the symbolic value of sustainability and its meaning for each interviewee, and (2) perceptions of participants regarding corporate sustainability targets.

Symbolic value of sustainability

Different participants had a different view of what sustainability was. The following comment from a GMSG person summarises well the participants' views:

'Sustainability is a different thing for [different] people. Let's say, you find a guy working in an area where you use metallic materials, then, for example, they don't know if they have lots of metals recycling, etc. Then in the mind of people in the business unit, it is metal scrap that is a problem. Then you have people from another business unit doing engineering of a motorcycle. What is important for them? It might be integrity, it might be product risk, customer questions. Then we have the third area where we have electroplating that it has many chemicals.'

Perceptions on corporate sustainability targets

The perception of the sustainability targets is another aspect of symbolic capital, and in this area the comments of respondents varied, but most of the interviewees supported it conditionally or unconditionally. The researcher observed that depending on the group, the respondent belonged

to, the viewpoint of sustainability targets was slightly different. The SG participants mentioned a need for continuous improvement, the LGs thought that there was a need to embed the targets at the higher management levels, while the BU level participant did not express any concerns regarding the targets, he focused only on the marketability of the products. The business people had a different point of view since they were stressing marketing criteria. Below are some comments describing this variability of perspective.

GMSG: *'We still have challenges in getting this to work really [well]. I think it is a really good process. It is still in theory but it is improving in practice. '*

CG project manager: *'When I showed the objectives at the department meeting, it was a manager who said to me after the meeting 'But it is only nice words from the Headquarters, it is not applicable here'. Reading the targets is very fluffy. How do we know if we have actually achieved them? We have no idea! We should always have sustainability part of the [process] and they are not there. There are so many things that are missing. We are a research department this is too subjective for us to keep up with it. Even though someone might have the will, it is not there. So if they succeed with embedding those and having the management teams working with it, then yes, it will be fantastic, but right now I don't see how they will succeed in doing that.'*

BU/LBU manager: *'I think what the company is doing now is good, they used that as one of the highlights to be clean and to work in an environmentally friendly way and to track energy for the customers. I think that is a good slogan and I am not sure we have to do so much more. At least from customers' perspective they see us and we advertise ourselves. How we can do it? Can we cut the energy by 30%? Certainly we can, we see it in the airports, in many airports when you land. I think that is good.'*

Even being satisfied with the performance in the area of sustainability, all participants, mentioned directly or indirectly that sustainability targets could be more ambitious.

While reviewing the data collected on the symbolic capital, the researcher observed that the perception of sustainability varied depending on the organisational context the interviewee came from. It is also worth noting the product marketing emphasis on sustainability performance, while there was not much interest in the processes with the exception of the CG Project Manager who has also worked for SG.

8.3.1.2.2. Interrelations

The interrelations, one more factor of cultural capital, was observed from two angles, the inter-group (intra-organisational) and intra-group relations of SG and non-SG regarding the sustainability targets. In the following sections, the researcher will discuss the SG and non-SG intra-group, and the SG and non-SG intra-organisational interrelations. The researcher asked the SG participants to describe their interaction with the people from the different organisational levels of their group and their interaction with other organisational groups on sustainability tasks. Non-sustainability group participants were also asked about their interaction with the sustainability group and the involvement of the people of their group in the adoption of the sustainability targets.

<u>Intra-group for SG</u>

In SG relations, the researcher observed that the GMSG team having a global view of the organisation trying to manage the complex issues arising from the company's variability and complexity. This did not allow GMSG team to focus on the lead of the lower levels. On the other side, CMSG put much effort into helping and informing the country network. However, the lack of guidance from the GMSG level affected the way CMSG saw this interrelation. Below is a comment of CMSG person who was describing their perception of GMSG:

'I really don't know what happens after when I give the feedback every quarter.'

While reviewing the Intra-SG data, the researcher observed that the SG persons were mainly describing the horizontal interrelation. In particular, the LSMs (including about sixty members of the staff in the chosen country) mentioned limited vertical interaction.

<u>Intra-group for other groups</u>

The BU/LBU manager who observed involvement of different people from a higher level mentioned:

'Some people feel stronger urgency to do something [on sustainability]. But it is not difficult to argue for the sustainability as such, it is when you have 10 things to do, maybe some people have a more urgency to others to prioritize.'

The researcher observed that all of the non-SG participants mentioned that choice between focusing or disregarding sustainability targets is a matter of prioritisation in their group.

Intra-organisational

The relations between SG and non-SG members of the groups could be considered as inter-group relations. The GFSG had a more innovative approach:

'The objectives were too inward looking for the sustainability function and weren't actionable out in the organisation. So that is why we had the ambition for objectives that cover the company, not just the sustainability function. They should be actionable at the local business unit level. People should feel: 'yes, this is relevant to us!'.

This approach was perceived well in the organisation, for example, a Line manager mentioned:

'Now it is more visual for you that things have to be done and you are part of the solution, you have to be involved and this is much better. It is much more work, but we have to do it.'

It seems that SG made an intelligent decision to involve responsible non-SG staff in the decision-making process. Nevertheless, the non-SG participants mentioned that their involvement was a matter of their priorities set by their managers who were not accountable or responsible. However, the SG was not trying to lead (provide options/directions regarding) the process for non-SGs.

8.3.1.2.3. SrCC summary

The cultural capital consists of two factors, symbols and interrelations. During the interviews, it became apparent that people from different parts of the organisation have a different view of sustainability depending on their group context. However, all participants mentioned that the company could perform better in the area of sustainability. When discussing interrelations, it seems there was a leadership gap on the corporate organisational level of sustainability, which might affect both the intra-SG and intra-organisational SG performance.

Table 33. SrCC summary.

Symbolic	Vision	Interrelation
Differing perceptions of sustainability are acceptable as long as they fit with their role in the vision.	1. Conditional or unconditional belief in vision's success. 2. Believe that can do better in sustainability.	**Inter-SG**: SG tries to improve interrelation by making non-SG members of the team participate in the process, which could be considered as beneficial. Non-SG people reaction depends on their priorities. **Intra-SG**: GMSG sets priorities globally, and CMSG networks interact with the LSMs. There is a leadership gap between GMSG and CMSG.

From the analysis of SrCC the researcher identified two main cultural capital issues, the first relates to the intra-SG capital, while the other one covers the intra-organisational (from SG's side) capital and applies to the way SG manages the interrelation.

8.3.1.3. Sustainability-related intellectual capital analysis summary

Based on the analysis of collected data, and in particular the data related to the assessment of SrIC-in action of company B, the researcher noticed some areas for improvement that pointed to dynamic aspects of the SrIC. In the following section the researcher will explore the data using the SrIC-detailed analysis conceptual framework. The highlighted areas for further investigation include:

a. Weak SrIC-in action capital of LSMs and its potential for improvement. LSMs are the key actors and the ones that influence action. Their SrHC enhancement probably would have a positive impact on their work with the non-SGs.
b. The SG vertical leadership gap between GMSG and CMSG levels. GMSG develop the sustainability targets, but they do not have a direct influence on the management of the country networks and this creates a leadership gap.
c. Considerable horizontal interrelation gap at the LSMs level.
d. Different priorities of SG and non-SGs. Judgement analysis revealed difference in philosophical perception of sustainability between the members of the SG and non-SGs that was also mentioned in Chapter 4.
e. The SG's approach to collaboration with non-SGs. GMSG leads the inter-group (intra-organisational) collaboration only through sustainability performance KPIs disregarding the importance of interactions between LSMs and people from other groups.

8.3.2. Sustainability-related intellectual capital detailed analysis

The highlighted SrIC-in action areas for further analysis are explored from the viewpoint of tactical strategy that the sustainability group uses and the relation of tactical strategy to the SrIC-in action performance.

Based on data observation and influenced by the IC literature, the researcher made a detailed analysis of SrIC introduced by the researcher in Chapter 7 (sections 7.5.2 and 7.5.3). This section further explores the concept of intellectual capital. In this section the researcher will refer to the dynamic part of SrIC and he will discuss factors that can influence the development of SrIC within the organisation. These factors represent knowledge that can be useful to the person responsible for the integration of sustainability aspects in organisational processes. The knowledge is comprised of the combination of sustainability leadership aspects with structural, information and group tactics that are analysed below.

Table 34. Detailed analysis IC factors.

	Factors	Aspects
Structural tactics	Infrastructure	The value coming from the structural layout of the organisation (roles description, org. structure, etc.).
	Process	Series of actions to achieve results (organisational processes).
	Renewal	All the processes that have been created to have impact on future value (e.g. training, organisational learning processes, repeated processes that increase knowledge).
Information tactics	Information systems	The way the information flows in the organisation.
	Collective knowledge	Mechanisms of providing explicit knowledge. This can relate to factors using knowledge in action, such as Ground truth, Rules of thumb.
	Measures	Data and information available on specific aspects to support decision-making.
Groups tactics	Focus of action	Action taken at each organisational level and its analysis in 4Ps (people, product, production, place), VC and TBL coverage.
	Motivation	Engagement of employees with business strategies.
	Conductivity	The activity and follow up of employees after being conducted to take certain action.
	Agility	Ability to transfer knowledge from one context to another, see common factor in two distinct pieces of information and link them, and improve both knowledge and output through innovation and adaptation.

During the data collection the researcher asked questions on all the different tactical factors mentioned in Table 34. The result of this data collection included quotes and cognitive maps (mainly on infrastructure, process, information systems, and conductivity) for each of the factors.

Table 35. Leadership capabilities (Posner and Kouze, 2012).

Factors	Aspects
Model the way.	Clarify and affirm shared values
	Align action with values
Inspire a shared vision.	Envision the future
	Enlist others in the common vision
Challenge the process.	Looking for opportunities
	Generate small wins and learn from experience
Enable other to act.	Build trust and facilitate relations (collaboration)
	Develop competences
Encourage the heart.	Showing appreciation for individual excellence
	Celebrate values and victories, community spirit

Then for each of the tactical factors, the researcher further analysed the collected data according to their link to the leadership capability factors (Table 35) that they referred to. The data were inserted in the template described in Table 28 and were further analysed (following the process described in 7.5.3) and the analysis template took the form it has in Table 36. The characters in Table 36 refer to the highlighted points mentioned in 8.3.1.3. and they will be explored further. The SrIC-in action points are linked to the majority of the slots highlighted in red

Table 36. SrIC-detailed analysis template of Company B case.

Capabilities	Leadership (Posner and Kouze, 2012)	1. Model the way		2. Inspire a shared vision		3. Challenge the process		4. Enable others to act		5. Encourage the heart	
		Clarify & affirm shared values	Align action with values	Envision the future	Enlist others in the common vision	Looking for innovative ways to improve	Generate small wins and learn from experience	Build trust and facilitate relations (collaboration)	Develop competences	Showing appreciation for individual excellence	Celebrate values and victories, create spirit of community
Structural tactics	Infrastructure		a1, d2		e1						
	Process		d2					c			
	Renewal				b		a3		a3		
Information tactics	Information systems							c			
	Collective knowledge						a2	a2	a3		
	Measures				e2						
Groups tactics	Focus		d1								
	Motivation		d1				a2			mis	
	Conductivity		d2					e3			
	Agility		d3		d3						

	lack of data
	data was available on only one axis of the table
	good performance
	performance needs improvement
	performance requires improvement and creates problems for other tactics and capabilities
1	**the connected slots are assigned the same number.**

The slots with the same letter relate to a specific IC-in action hotspot and the slots without a hotspot letter are other points of interest that do not relate to the hotspots.

a. The weak SrIC-in action capital of LSMs and how it could be enhanced

This section provides a description of the analysis related to the a-marked slots of Table 36.

a1. LSMs working time

These data relate to the infrastructure tactic and align action with values leadership capability, because the roles are considered as structural component linked with the way they align within the organisation sustainability targets.

The researcher asked the participants to mention their roles in the company and during the interview, the researcher noticed that some participants had multiple roles. Therefore, the participants were asked about the share each role took in their working time.

Table 37 describes the roles of participants (the roles were mentioned by members of the group who participated in the interview). Since this was not part of a question, it is possible that some people might have had more roles. It came out during the interviews that the LDSM and the LSM had at least 2 or 3 different roles.

Table 37. Participants roles analysis.

Roles			Number of people	Roles mentioned	SG related roles
SG	GMSG		**2**	**2**	**2**
	Country network	CMSG	**2**	**2**	**2**
		LDSG	**1**	**3**	**3**
		(LBU/LG)SM	**4**	**8**	**5**
Non-SG	Other CGs	CG Project Manager	**1**	**2**	**1**
		LG Manager	**1**	**1**	**-**
		LG Division Manager	**1**	**2**	**-**
	Divisions	BU/LBU Manager	**1**	**1**	**-**
		Line Manager	**2**	**2**	**-**

During the interviews the participants mentioned the percentage of time members of the team spent in the capacity of LSM. In one case the role of LSM took about 60% of the person's time, while in the majority of cases time spent on LSM varied from 5% to 20%.

Some respondents mentioned that time, resources and knowledge limitations were the main reasons of inefficiency at LSMs level. Below are some comments on the time, knowledge and resources limitations of LSMs.

LBUSM-2: *'I think it is the main problem. You have to have time and you know how to do it, but often you don't get the time and the resources*.

LDSM: '*So many of them don't have the time and don't have the knowledge and so on*.'

LSMs schedule was full of tasks where LSMs did not feel competent and this did not help in the development of sustainability-related process. Also, LSMs did not have time and resources to develop their competences.

a2. Reinventing the wheel

The data in this section relates to developing collective knowledge tactic and discusses two leadership inefficiencies that were identified during the analysis. The first inefficiency concerns learning from experience and the second is on lack of collaboration.

Interviewees mentioned that some of the resources were not available to all members of the team. Therefore, people with no access to the information had to find it on their own. In the case when all the members of the organisation receive equal access, this allows to save time and effort of employees. During the interview, the lack of the information was discussed.

An LSM was mentioning how difficult it was to find information on an SG task while one of the members of the team (who was present in the room during the interview) had developed a relevant tool on that four years ago. However, the LSMs were not able to receive access to it. This presents an example of wasted resources and LSMs time and potential. Below are the quotes regarding the issues that were identified during the interviews.

GMSG person: *'Four years ago, it is called [project name]. It was a steering group we covered [emission categories], and calculated CO2, we made a tool and a supportive study with examples, it should be available to you.'*

LBUSM-1: *'Our [LDSM] manager didn't know anything about it. That is the problem [for Company B], because I was sitting here in the [same] company. And now we are doing it again. So do we really need to do it again? And I am sure I am not the only person doing the same thing.'*

Below is another case mentioned by another LSM, who discussed LSMs working on the same issues alone, while some of these issues could have been addressed centrally.

LBUSM-2-: *'I believe we have a network and sometimes I got the feeling that a lot of people are working with the same questions and make similar decisions but not exactly the same decisions. For example, following up the legislation, every division is doing that in a different way. Almost the same, but not quite the same and I believe that is one thing that could be done exactly in the same way.'*

LSMs do not have an efficient system of using available resources and network, and this limits their potential for further development and continuous improvement.

a3. Organisational learning

This section discusses a multi tactic and capability point. It highlights the absence of a renewal tactic process that could be led by acquired experience. In addition, taking a lead and sharing experiences and best practices has proved to motivate and to direct SG persons in taking action. The interviews also showed that other organisational groups have the leadership capability to establish collective knowledge processes that feed organisational learning.

The interviewees were asked about a presence of an organisational learning infrastructure, and unfortunately, most of the replies were negative. The only exception mentioned by the interviewees was a list of BAT (best available techniques). The comments presented below address collective knowledge mechanism that potentially could have made the work of LSMs easier and helped them to deliver better and quicker results. Many of the LSMs were struggling to fulfill their functions because of the limited knowledge transfer on sustainability issues within the organisation. During the interviews several LSMs mentioned that they did not have the time and courage to find this information on their own.

Below there are examples from the discussion with LSMs regarding benefits of the collective knowledge mechanism.

LBUSM-1: *'I think maybe the energy analysis/saving projects that we need to do. How do we do this? We don't know what it should look like. I think it should be good if we were given a template, this templates steps to deliver results. That is the way it should look like. That would help us a lot, because then we could say: 'Can we do this ourselves? Yes? No?' If no, we need to get some help from someone.'*

LDSM: *'Making checklists and also making ways to know how we can trust the information from suppliers and also how to know where to begin, to follow up the suppliers. How will we make a risk analysis? And I believe that these questions are not unique for our division, not unique for our BU, it is company questions.'*

Below there are several comments of LSMs who stated that when the knowledge was available, it enabled action.

LBUSM-2: *'We got a paper from CMSG with good examples from different units. Sometimes that can be good to get inspiration from, yes.'*

LDSG: *'When you are just introduced to something, maybe the knowledge and the wheel is very high and then after some time, new ideas, new things are coming.'*

The comments below show that other CGs had a process of exchanging experience and knowledge on sustainability-related issues even between different countries. In these interviews, LGs were discussing how they were introduced to a process of best practices exchange:

LG Division manager: *'It [exchange of best practices] is more on a country level, the [LG division] manager from a division we have more and more communication with other countries, which is making it easier to see what others are doing and try that too.'*

LG manager: *'We work together with the people from [country name] in a project called [name]. We have a discussion and we learn from each other. Some parts they do a little bit better than we, and some parts maybe we do better.'*

The collective knowledge infrastructure could provide a potential solution as there was a need for it and it has already worked in other CGs.

Summary of point 'a'

Creation of an information infrastructure should have helped the LSMs to become more efficient in fulfilling their tasks. The LSMs were lacking the human capital to support the process on their own. Moreover, there was a need for the development of an information infrastructure that would provide necessary knowledge through time to deliver the sustainability targets that were supposed to become more ambitious. The development of a collective knowledge mechanism would have helped to improve the use of resources and to promote a culture of organisational learning. Table 38 describes three issues that were discussed in this section.

Table 38. Summary of point 'a'

LSMs resources	'Reinventing the wheel.'	Organisational learning
LSMs had limited time, knowledge and resources for their tasks.	It seems there were useful resources that were not available for the LSMs. The availability would have saved time and effort.	There was limited evidence that SM had a culture of collective knowledge. The opposite could have made LSMs and non-SG people more efficient.

b. The SG vertical leadership gap between GMSG and CMSG levels

In the section the researcher provides a description of the analysis related to the b-marked slots in Table 36.

This section covers a problematic renewal tactic. Providing feedback is considered as an important aspect of leading a team and it helps to create a common vision around the sustainability targets.

Interviews demonstrated that there was no feedback flow from GMSG level to CMSG level, and this created a leadership gap at lower levels.

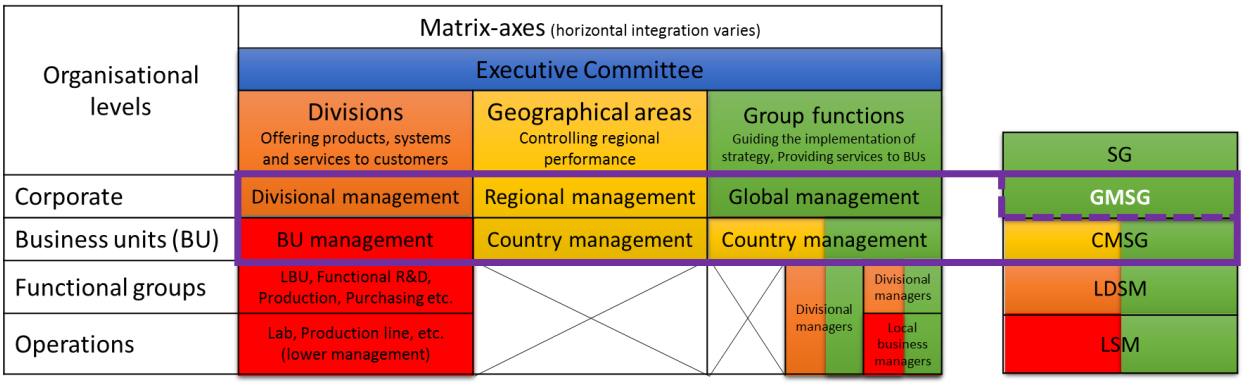


Figure 51. GMSG consultation input.

Figure 51 describes the information input of GMSG, a team that was involved in consultations and helped to create a balanced set of sustainability objectives for company B. GMSG team was receiving feedback from other parts of the company. A member of the GMSG team mentioned:

'Comments and possible solutions. So, to summarise, it is maybe hundreds of pages of information we got from different people that we had to analyse. Lots of comments and ideas from about 30 consultations. Now we renew these consultations. We will not stop this.'

On the other hand, GMSG did not provide feedback to CMSG; the other CMSG member said:

'From group function level [we do not have] control on this. So we expect them to make a plan based on this. We set the priorities and we expected solutions to come locally. We have 60 like CMSG people globally. We have about 150 countries. We can't say how it looks like in South Korea, for example. It is very difficult to say that. We must rely on people in this. It is a network of people that must work I think.'

At the same time, the CMSG members who participated in the GMSG's consultations, did not received feedback on their performance, while, CMSG in many cases provided feedback to the country network members. This seems to create a leadership gap for CMSG. Below are the CMSG comments on the lack of feedback from GMSG.

CMSG-1: *'I have to report, but I have never received any feedback on the quarterly report. It seems like it really doesn't matter. You just fill in something and nothing happens with it. But I mean if the group did not like the way we handled [it] here, if this was not what the group wanted, if they said this is not what we wanted with the environmental goal, why are you not doing this and this and that, I don't know where in the process we would get that feedback. Because we never had a comment on our feedback.'*

CMSG-2: *'We get the targets here and I would say that during all this process we do not have any dialogue from the group. And then, we have to feed these plans to the group, we send it to the group, and that is our feedback to the group, but we don't have any dialogue with the group here.'*

The one-way feedback between GMSG and CMSG limits the potential for continuous improvement and reduction of 'knowledge' gaps. On the other side, the non-involvement of high-level management in both SG and non-SG creates a 'doing' gap.

c. The horizontal interrelation gap between LSMs

In the section the researcher provides a description of the analysis related to the c-marked slots in Table 36.

This section discusses a process issue that could be potentially improved through the development of organised information systems. Organised information systems could have improved the collaboration between colleagues of the same group and at the same level.

To enhance the implementation, there is a need for an organised information infrastructure that will support LSMs. Based on the comments, LSMs interaction needed improvements while at the moment when interviews were conducted LSMs did not have access to each other. Sometimes process or information bottlenecks were created. For others, the interaction was limited or not organised. Below there are comments regarding the potential improvement of LSMs interaction.

LBUSM-2: *'We could have more use of each other, when we get a goal that we can sit together, or have a telephone conference and discuss in what way could we improve in this area and to get tips from each other and what kind of actions, certain goals could have.'*

LBUSM-1: *'We need to cooperate with the others ones they work on the same thing. Everyone is asking the same thing now, because you ask all the companies to do this this year which makes it difficult to get some help and some focus. Because now there is a system where you don't get the help you need while everyone needs to do it on the same time.'*

LBUSM-1: *'I think the communication between the property manager that is responsible for the site at real estate and that is responsible for the site at the LBU, I think that communication is really good. They have regular meetings, really good contacts. But then we have the LSMs at real estate, and the LSM at LBUs. There is no regular contact here really.'*

During the interviews, respondents mentioned some opportunities for improving the interaction by utilising online platforms that allow to communicate with each other and to avoid bottlenecks by populating information easier. Moreover, the interviewees from CMSG and LDSG mentioned that they had no or minimal interaction with people who worked at the same level in other countries.

Summary of points 'b' and 'c'

The analysis allowed to identify issues at various levels that involve the intra-SG links among SG nodes. First, the GMSG did not play an active role in the intra-SG and intra-organisational knowledge creation process. GMSG provided limited guidance to the lower levels of SG which created a leadership gap in the group. Second is the collaboration gap among people from the same level; the intra-organisational structure had a matrix structure, while the intra-SG structure had a divisional structure. Except for the information/knowledge infrastructure, the members of LSM required a contact with others as their time was very limited for fulfilment of their tasks.

Table 39. Point b and c summary.

Leadership gap (Vertical; point b)	Collaboration gap (Horizontal; point c)
There is no feedback both from High level and Medium organisational levels, which creates a leadership gap at the Medium and Lower levels.	The interactions and ways of communication and support are limited.

d. Differences in prioritisation between SG and non-SG

In the section the researcher provides a description of the analysis related to the d-marked slots of Table 36.

d1. Motivation for action

The researcher discusses motivation for action because of the way groups focus and motives are reflected on the way individuals align their actions.

Motives

This section will discuss the motivation of non-SG persons in taking action on sustainability issues. The interviews with the participants showed that certain group priorities played more important role compared to ethical issues ('moral case'). The latter was mentioned by some of the respondents, but it was outweighed by the business case. Below there are several comments showing participants that paid more attention to business issues compared to ethical issues (more emphasis was put on the business case compared to the moral case).

The interviewees highlighted business priorities importance while discussing sustainability targets. The BU/LBU manager provided a representative comment:

'No one is really objecting to sustainability. I think it is easier to say yes to it. But it is also one more thing you have to do. When you have a lot to do, you have to prioritize what is more urgent for the business. There are some people burning for it more, feel stronger urgency to do something. But it is not difficult to argue for the sustainability as such, it is when you have 10 things to do, maybe some people have a more urgency to others to prioritize.'

It was very interesting that a member of the SG had a similar point of view and accepted that sustainability targets are not in the first line of priorities. The LBUSM-1 commented:

'I think that, if you have to deliver something for a certain date, then that is more important. It is not like people don't care. The people that are in charge here, they really think it is important so that is really good. But sometimes the reality comes in.'

Focus

In Table 40 the researcher provides several comments on the priorities of different groups. According to participants' comments, sustainability played a less important role compared to economic benefit, or safety (in the situations of high risk), however, some interviewees mentioned that under certain circumstances sustainability targets were prioritised.

Table 40. Group priorities related data.

	Group priorities	Profit/Costs	Stakeholders	Sustainability
CG project manager	*'Innovations are top one, increased product performance, how do we do better products'*		*'Customers are also very important. We are here to fulfil their wishes or even exceed them.'*	*'Sustainability is behind. There is a gap. It is a cost issue. We are not looking at the details, it is mainly the cost of doing it.'*
LG manager		*'Cost is the first, everything should be cost-efficient.'*		*'Health and safety is competing cost.* *We have been a little more focused on HS but I don't think it has been forgotten E, Health and safety has been a focus for very long and my feeling is we have E is in control, we always have to work with it but we are quite happy with it. It is just a feeling I'm not sure.'*
LG Division manager	*'Lead-time, time delivery'*	*'Cost savings is the driver'*	*'Legislation here or in customers' countries.'*	*'Actually it is not environmental or safety for our function.'*
Line manager (1)			*'Customer is always first, the local government is also important. Both come to see the production and will point it out if they are not very satisfied.'*	*'Safety is very important for us. The environmental is not one of the biggest topics in our organisation . The environmental is also an economic issue.'*
BU/LBU manager	*'Performance and quality comes very high in my world.'*	*'Profit is very important.'*	*'Competitors and customers are very important. We need to cover the needs of the customers and do it in a better way than competition in order to be a successful business.'*	*'Sustainability comes lower. If we can connect it to some business unit, it comes higher up. The country has this responsibility. Health and safety is even more important than anything else before we start to talk about profit etc.'*

The cost-efficiency of sustainability targets was mentioned a lot by the SG and non-SG persons as an aspect that can enhance the position of sustainability in the priorities raking. For example, the LG manager mentioned:

'It is an important driver for people to feel that this is good and when they see that it is cost efficient to do, it is much better.'

The interviewees that represented SG mentioned the importance of cost-efficiency. However, the reaction of the core-SG levels was different. For instance, a CMSG member mentioned:

'When we talk with other groups on sustainability, from their side it is all about money, money, money. All their improvement works are focusing on money. It does not help that sustainability is important as well, not until you start to measure the performance and in this way translate it to money.'

During the analysis of the transcripts (Table 41) where interviewees discussed different pillars of corporate sustainability (TBL), it became obvious that SG interviewees did not address the economic/business aspect clearly.

Table 41. Participants views of different aspects of the TBL.

Roles			Business	Environmental	Social
SG	GMSG		Vague	√	√
	Country network	CMSG	Vague	√	√
		LDSM	Vague	√	X
		LSM(LBU/LG)	Vague	√	√/1X(LBUSM)
non-SG	Other CGs	CG Project Manager	√	√	√
		LG Manager	√	√	√
		LG Division Manager	√	√	√
	Division	BU/LBU Manager	√	√	√
		Line Manager	√	√	√

The analysis of the motivation for action shows that non-SGs were aware of the sustainability aspects, but they had to take action on sustainability while deciding on priorities at the same time. As the analysis showed the sustainability targets usually were not high on the agenda. It was also mentioned that if the sustainability targets constitute a business case, the rank of

sustainability would increase considerably. On the other side, SG participants were not clear in addressing the business aspects of sustainability. Therefore, there might be a need to enhance the knowledge of the SG in creating business cases for sustainability.

d2. Conductivity

Conductivity shows how members of the organisation align their actions with the values that they are supposed to follow in practice. The collected data demonstrate that other tactics such as infrastructure, process and motives influenced conductivity.

This section will discuss the conductivity between SG and the rest of the organisation. As said before, the SG made an attempt to involve non-SG persons in the process. However, SG has no power to command other parts of the company. A member of the GMSG team mentioned:

'We are not a 'command and control' function in that sense. We cannot command and control, we can influence and we can set priorities and we can share best practices. And we do not provide the financing for implementing this, that must be argued and agreed locally.'

Some of the participants at LG side believed that their responsibility did not include addressing sustainability targets because their management did not address it. The CG project manager mentioned:

'When asked the manager on sustainability targets he said it is not part of my job. 'It is not his job!'

In regard to the LG Division manager said:

'We are trying and a lot of them [representatives of other functions] are also agreeing that it is important, we discuss it, but on emissions that is the main thing no one talks about it on the decision time.' An LBUSM-2 describing another case mentioned: *'I have talked to the [LG] manager because I think that is something that I think should be part of his work. But his managers, they are not asking for this. So, he did not come back to me.'*

A CMSG member provided an explanation on the limited commitment from the LG side:

'If they don't get their message from their central group function, it doesn't help them that the central group sustainability ask to work with sustainability. And it would be the same for me. It wouldn't help if the manager globally of another function would say that I have to do something, if the sustainability globally don't tell me, then I won't do it.' Moreover, the LG manager provided another perspective on limited conductivity: *'If it is not asked, you will put are going to put the*

energy that you have into what you will be counted on. How is my performance measured and sustainability today is not there? So all the other issues will come before.'

From the LBUs side, it seems that the personnel paid attention to sustainability only when a sustainability aspect became a priority for them. Below are two comments describing the situation.

LDSM: *'Some years ago when I informed people about ROHS for example, they did not pay attention. But now that is a market priority. Come to me and tell me how to do it, give us checklists.'*

LBUSM-1: *'When I came to this LBU, the performance assessment on the sustainability targets of the LBU was bad because of no action. The managers thought that this [was] not good for their profile and came to me and told "Help, we don't know what to do, how do we do this?" '*

This shows that the way the organisation functions did not allow SG to influence the process. There is a need for SG to present the sustainability aspects in a way the non-SGs count on. This can give the non-SGs additional incentive to prioritise sustainability.

d3. How is sustainability value conceptualised?

This section will discuss an agility tactic issue, when the leaders put more emphasis on letting the groups to find their own way to align with values without enlisting them under the common vision (i.e. sustainability targets).

In this section, the researcher will discuss presentation of sustainability value to influence business unit and members of the SG. In company B, the SG was more focused on the creation of a balanced plan compared to business cases. In this regard a GMSG person mentioned:

'We have to balance to make it up to lift to a higher level. I don't think we have any gaps, but the question is more to find the right balance between sustainability questions companywide. We should include everything and not forget everything. But you can't point every problem everyone wants to face so when we have hundreds of problems, balance is a problem. So completeness would keep the balance and not point out [to] one specific area.'

The LDSM brought up this issue mentioning*:*

'There could be a better way of communicating exactly how important this environment is, because if as a company [we] focus only on sustainability, we will sell nothing. This would be good to get more information and more support in communicating sustainability properly.'

From the comments, it seems that at this stage the core of SG (GMSG and CMSG) puts less emphasis on making business cases, in contrast to the non-SGs who highly value them. The researcher believes that the core part of SG needs to embrace sustainability business cases in order to introduce them in their operation and to pass it to their ambassadors (LDSMs and LSMs).

Summary of point 'd'

This section focuses on the alignment of actions to meet the sustainability targets while taking into consideration individual groups motives (Table 42). When the interviewees were asked about their motivation and conductivity to deliver the targets, the non-SG participants mentioned that their actions were a matter of their priorities, and the sustainability targets were not among their main priorities. The difference in priorities between SG and non-SG did not allow to establish a functional collaboration. This difference impedes SG in creating the sustainability targets. SG puts more emphasis on creating a balanced plan than making business cases for both SG and non-SG. It seems that SG should develop the targets locally and provide an opportunity to non-SG to get involved in a process of setting the targets, using synergetic business case approach, and emphasising the sustainability targets. The existing difference in priorities reveals an existence of a 'knowing' gap from the SG side while non-SG would follow the targets set by SG, if they were presented the right way.

Table 42. Point d summary.

Motivation for action	Conductivity	How value is packed (presented)
Business priorities dictate actions at LBUs/LGFs with an emphasis on making business cases.	SG tried to influence the rest of the organisation to take the action. The response from LGs and LBUs was a matter of each group's priorities.	SG was focused on creating a balanced plan that covers the company's activities, but it is not packed in a way that implementers will see the business value.

e. SG's approach to leading collaboration with non-SG

In the section the researcher provides a description of the analysis related to the e-marked slots of Table 36.

e1. High-medium and Medium/ lower level gap

This section focuses on how the leaders of the sustainability group use the infrastructure to enlist other organisational groups in the common sustainability vision.

<u>High/medium</u>

The high-level management were consulted in the process of developing the sustainability targets but the non-SG members of the team were not responsible or accountable on sustainability. During the interview, a member of GMSG described the list of people who were consulted.

'This is a late consultation with a business person, this is an earlier consultation with a sustainability controller in the US, and this [is with] China sustainability person, this is a Columbia sustainability person, this is an Italy sustainability person. This is a late consultation with operations excellence, plus R&D manager. The R&D manager is in the executive committee. So it's high level people here. But later the consultations are more business people. The earlier consultations are networks, sustainability networks.'

From some of the interviews, it became obvious that high-level management was not informed, and therefore there was no pressure from a higher level to work on sustainability issues. As it was discussed earlier the pressure was imposed by LSMs or the customers. The CG project manager and the BU/LBU manager who had regular contact with high-level managers mentioned.

GF project manager: *'If I was a regular manager (and not have worked with SG) that would already receive the information from the department manager I would not have seen the targets because those have not been communicated here. They are not embedded in this part of the organisation.'*

BU/LBU manager: *'There is no one pushing us to make more environmentally friendly products. [It does not go beyond] discussion with [LSM], no I don't know that, nothing comes from Division or something. Very much business driven, the product efficiencies came from the customers that they started to ask for it and when we saw several customers coming to ask for it.'*

Moreover, the LG Division manager who was at a lower level mentioned:

'The manager of the manager did not ask for it. And when he doesn't ask for it, they [the lower level managers] do not see it as important because it's never asked for it from his manager.'

The same interviewees mentioned that high-level management could serve as a catalyst for action on sustainability issues.

CG project manager: *'The high level management of the CG can have an influence. If they ask for it, [this] will happen.'*

BU/LBU manager: *'I think that if you can find something that is driven by business to use that to leverage the products more than just to start something that people do not think is linked to the business. If you can do that it will work.'*

High-level management involved in the consultations was not responsible or accountable for sustainability targets, while they were the main intra-organisational catalysts for action at the lower levels.

Medium/low

At this level, the responsibilities were set, but sometimes the complexity of the matrix organisational structure made it hard to identify and to assess personnel. A CMSG person expressed this in the following way:

'If they don't get any directives on sustainability from their managers, it is more difficult for us in the matrix from the country level to have some impact.'

Due to the intra-group high/medium levels gap on sustainability issues, the inter-group (intra-organisational) collaboration at the medium/low levels was not possible, and therefore, the members of the organisation did not collaborate while working on sustainability targets.

e2. Measurements

This section focuses on the comments of the interviewees discussing the cases where the measure tactic was not used properly to enlist others.

It is difficult to manage aspects that cannot be measured, therefore, measurements that allow to develop a baseline play an important role in collaboration with non-SG members of the organisation. The availability of data, or better quality data is another important aspect of the information component.

CMSG: *'The data we have is really poor. And the data is really-really important. I think we needed to put more focus on getting accurate data. Even for measuring carbon dioxide for example. Because we don't have a unified measurement system where we can track things on every level, not even in a division. So it's hard to find a common system where we should implement CO2 system is not so easy.'*

LBUSM-2: *'There is no good way of measuring it, they say we need to reduce CO2. We need to focus on this, but we don't. Number one we don't measure it. So then it is difficult to set a goal.'*

e3. Code of conduct

This section focuses on the way the sustainability group uses conductivity to initiate collaboration with the rest of the organisational groups.

The analysis allows to conclude that the interactions between SG and BUs and CGs require change from patrolling to collaboration, since this change will help to create sustainability-related business cases. From the comments below it is possible to see that in some groups respondents were not aware of the existence of the LSM in their group, which cannot be considered as examples of good practices.

GF project manager: *'So as you heard, [LSM name] did not know what an LSM was before she was asked to be one. Because that person that had it before was not visible within the organisation . So I think, you have to be out to the different departments and groups, showing off the face of what you do and that wasn't there before.'*

Taking into consideration the latest comments it is possible to address another case at the LBU, where the relation with the LSM was very productive and the LSM was considered as a part of the team. These productive relationships can be considered as an example for LSMs intra-organisational relation.

LG Division manager: *'The LSM is pushing from the side: "What are you doing to show that you are doing something better?" "Environmentally do you have a new aspect?" It is more interactive than the previous. [LSM name] is more interactive than the previous.'*

BU/LBU manager: *'I think now we have a working relation with her (LSM) and I think she can be [more than] a police. She takes more active role, she wants to help more. Initially when she started in this role, she [was] more pointing out things, but when the time changed, maybe she has also realized if she wants to have things done, it is a way to work together with us. I think now it works very well. We invite her to our monthly meetings and [to] some weekly, if we need her input or feel that she needs to be up to date.'*

The examples of good interaction should be used as guides for other parts of the company where the SG is distant from non-SG groups.

Also, one of the interviewees mentioned a case when a member of the team had a question related to a sustainability target, and he did not receive any guidance, because the team could not find anyone knowledgeable on sustainability issues from SG or their CG.

CG project manager: 'It is like coming back to the nine new objectives, this [objective title], who is going to tell us which are the right […] to work on. Who actually has that task? Who is responsible? Because we feel that we should be responsible, but here no one is accountable for that thing. We think that GMSG will come and tell us but they won't because there is no one there, who is accountable for it. So I think these are huge issues. Because we had an issue last fall that was quite controversial. We were working within one of the projects and I tried to figure out if it was ok or not to continue to use a material and I could not get an answer, no one would tell me. Not the person that was sort of the manager, not sustainability people, not the LSM at that time could not tell me, so no one could tell us if it was ok or not. And I think that this is an issue that no one is accountable, no one has it as 'my task to work with that issue'.'

When the current SG infrastructure cannot guide other teams on targets already communicated by SG, this does not cultivate a good link between two nodes.

Summary of point 'e'

In company B, GMSG was focused on the aspect of 'learning by doing': the member of the team was trying to capture new knowledge by exploring the explicit side. For example, GMSG received knowledge from the high-level management of the organisation during the consultation. The consultation participants were involved in guiding and controlling LBUs/LGs, but at the same time they were not responsible or accountable. Sustainability issues were not high on their agenda, and this was reflected in the priorities of the LBUs and LGs. To raise awareness of high-level management, SG had to convince the non-SGs that sustainability targets should be considered as a business priority. This demonstrates an existence of multi-tactic hotspot aimed at developing a collaborative structure to enable actions on sustainability issues. The analysis of SG inter-group (intra-organisational) collaboration showed the importance of measurements for SG to support the development of business cases and to change from the conductivity mode of patrolling to the mode of a business partner. Table 43 describes the issues that have been covered in this section.

Table 43. Point e summary.

High/medium level gap	Medium/lower structural gap	Measurements	Code of conduct
The leadership of non-SG. They were consulted to create the shared vision, at the same time these people were not responsible or accountable.	At this level, the responsibilities were well defined, but the matrix complexities sometimes made it difficult to identify and to assess members of teams.	Without measurements, it is challenging to manage it.	LSMs need to swap from patrolling to collaborating to help and to guide LBUs/LGs in creating business cases for sustainability.

8.3.3. Feedback

The result and observations of the last focus group is described.

In October 2015, the researcher returned to company B to present the results of the case, to discuss the suggestions of the researcher and to seek the feedback from employees. Before the meeting the researcher decided to send a thirty-minute video presenting the results of the case along with a set of questions for discussion. The researcher hoped that the video and the questions would allow participants to reflect on the results so they would provide more information during the meeting and discuss the follow-up steps.

On the day of the meeting, the GMSG and CMSG team, the CG project manager, and the researcher met to discuss the results. The researcher went to the meeting with expectations for a long discussion on how the SrIC of the company can be improved, especially after suggesting solutions in the video already shared with the employees.

It was interesting that before the beginning of the meeting all the participants individually and privately mentioned their approval of the results presented in the video to the researcher. However, during the meeting none of them stated their opinion openly until the senior GMSG person mentioned that the content of the video was very informative and useful. When the meeting started the senior GMSG made a short general introduction where he mentioned that he would like to go through the video content again in the form of live presentation to discuss it. Through the discussion the researcher was not able to obtain new information, because most of the participants mentioned things they stated earlier during the interviews or agreed with the statements the others provided during the interviews. The important thing was that the

participants started discussing with each other points made in the presentation which shows that the research raised issues that were not discussed before.

At the end of the meeting, the researcher repeated the proposed interventions, so the participants mentioned that they were planning to take actions on improvement of competences and collaboration of the LSMs and stated that this project helped a lot to make that decision (point a and c). While discussing other interventions, the GMSG persons mentioned they saw the need for better organisational management and leadership on sustainability, but this was a task for the human resources CG. At the end of the meeting during the discussion of the leadership gap, an unexpected incident took place: the senior GMSG person closed the meeting, while not making any comments on leadership. Then a CMSG person said: *'do not forget the leadership, the leadership… is very important'.*

The researcher also asked a group of GMSG personnel if they think that they could use the SrIC conceptual framework on their own, the answer was: *'This does not seem possible because it is a very complex tool for us, it is even hard to understand the method. It is a very useful tool with very useful output, but too complex to do the analysis on our own'.*

The researcher believes that sending the video in advance was not a good choice because possibly without the video presentation the participants would have been more active. It seems the team at that time was not ready for discussing solutions.

After the last focus group, the researcher interviewed an experienced sustainability consultant who works for company B and who has cooperated with the participants of the study in the past as a member of the SG and at the moment of the interview he cooperated with them as a member of another CG. The consultant approved the results of the study and mentioned:

'Sustainability is a small group with limited resources that tries to improve the sustainability performance of [company B]. They are very successful and have long history on the scientific aspect of sustainability, especially the environmental aspect. The last years, they tried to develop the management aspect, but they have long way to go'.

8.4. The link of LCM factors with knowledge development and SrIC

The analysis of LCM factors and knowledge conversion factors enhances existing knowledge on the link between LCM factors and knowledge conversion.

The initial data collection on sustainability processes allowed the researcher to study the fit of the LCM factors and their link with the knowledge development mechanism.

The LCM factors were introduced in Table 14. In this chapter, the researcher explores the applicability of factors to case B and to the way company B integrates sustainability aspects in organisational processes.

Table 44. LCM factors fit with company B.

LCM factor	Fit with case
Highlighting	Is prioritising the initial sustainability issues to commence the consultation process (more information in Appendix 4).
Collaborating	CMSG and LSMs work at the organisational processes level with the rest of the groups on sustainability targets and other individual issues might appear.
Analysing	nternally, there is a long tradition of the environmental analysis in company B; SG is conducting LCMs and other types of analysis for more than 25 years.
Strategising	It is the result of the GMSG consultation process.
Decision-making	It is the result of the CMSG consultation process.
Implementing	Implementation is with the responsible and accountable groups around the organisation.
Sustaining	LSMs as local ambassadors at the various organisational groups assess the performance and in collaboration with CMSG try to influence the sustainment of the processes and further integration of sustainability aspects.
Developing knowledge	It was mentioned by GMSG that they will continue the consultations, and the CMSG will continue collecting feedback from the network. Nevertheless, there is limited knowledge on the way company B uses the obtained experiences to enhance the development of sustainability aspects integration.

The researcher analysed the collected data from the initial focus group on the sustainability-related organisational processes. The processes described in Table 44 demonstrated that all eight LCM factors proposed by the researcher in Chapter 4 were valid.

In addition, taking into consideration the SECI and knowledge conversion components described by Nonaka and Takeuchi (1995), the researcher again analysed the collected data. Table 45 describes the fit of the data with Nonaka's and Takeuchi's components.

Table 45. Fit of knowledge conversion modes and triggers (Nonaka and Takeuchi, 1995) with company B.

Knowledge conversion modes / triggers	Fit with case
4. Combination	GMSG inter-group consultation phase.
A. Learn by doing	GMSG learns from the comments/suggestions of other groups.
1. Internalisation	GMSG integrates the different bits of information.
B. Field building	GMSG has a holistic vision for the company's sustainability targets globally.
2. Socialisation	Intra-SG manages the targets locally.
C. Dialogue	SG discusses and apply locally with LG/LBU.
3. Externalisation	Inter-SG communication of sustainability performance locally/globally.
D. Networking	At the organisation level among others discuss sustainability performance locally/globally.

During the analysis the researcher observed that many of components in Table 44 can be linked to various modes and triggers mentioned in Table 45. For example, the consultation phase initiated by GMSG is described as a Highlighting LCM factor process in Table 44 and a Combination knowledge conversion mode in Table 45. Furthermore, the result of the consultation process is a strategy LCM factor in Table 44 and a Field building knowledge conversion trigger in Table 44. Through analysis of the connections between Tables 44 and 45 the researcher observed that the flow of LCM factors is not linear, whereas the flow of knowledge conversion as described in Table 45 is linear. This observation strengthens the researcher's suggestion (mentioned in Chapter 5) that developing knowledge is a key that unlocks better LCM performance.

The LCM conceptual framework is used here to address the continuous improvement objective through the knowledge development mechanism described in Chapter 7. Based on the analysis of Table 45 the fit of case B with the knowledge development mechanism is described in Figure 52.

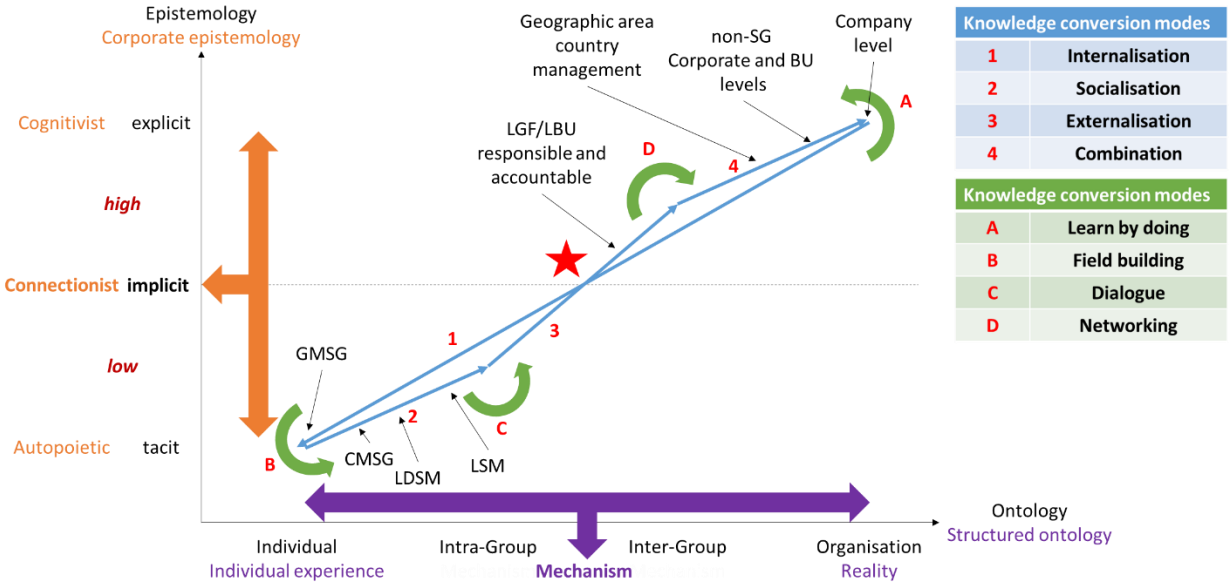


Figure 52. Knowledge development infinity loop fit with case B.

The consultation phase of GMSG took place at point A and it resulted in point B, where two members of the staff who developed the group sustainability targets had to spread knowledge and to inform the organisation about these targets and to return to point A through the infinity loop-shaped process. At point B, GMSG had tacit knowledge related to the corporate sustainability targets, and GMSG participated in the transformation of this knowledge into explicit when it would reach point A again. It should be mentioned that the distance between points A and B (indicated by arrow 1 in the Figure 52) represents the formation of tacit knowledge. Whereas, distance between points B and A (indicated by arrows 2, 3 and 4) represents implicit knowledge development that converts tacit knowledge to explicit.

The researcher observed that the learning process and knowledge development were very important for the continuous improvement objective of LCM. Because of its importance the researcher developed the SrIC conceptual framework by using observations from the initial case and applying 'filters' from the IC literature. This chapter is devoted to the sustainability knowledge development described in Figure 52 by the distance between points A to D and not D to A.

8.5. Summary

The researcher used the SrIC conceptual framework to analyse how company B develops, decides and implements their sustainability strategy from a knowledge development perspective. The researcher is confident that SrIC can help to analyse and to enhance the integration of sustainability aspects in organisational processes of company B. However, it is doubtful that the obtained knowledge can be generalised to other cases. At the same time, it should be noticed that this case is the only analysis of SrIC available in the literature.

The approval of the participants of the results of this research shows that the sustainability group of the company lacks competences in the management and leadership of sustainability-related information integration in organisational processes. Through this case the researcher showed that SrIC conceptual framework can be used in the assessment of the current SrIC competences of the sustainability group and can support proposed interventions.

Importantly, this case also allowed to observe that the sustainability group was competent in sustainability analysis (objective 1), but lacked on the integration management (objective 2) and continuous improvement (objective 3).

This study focused on the organisational processes level and the LCM sustainability analysis (objective 1) was not analysed in detail. However, within the framework of the SrIC analysis certain issues were addressed like the widening of measurements focus as part of the continuous improvement objective (objective 3).

The researcher observed that SG did not lack personnel that was able to analyse the products lifecycle by using a holistic approach, however, SG used the LCA experts focusing strictly on providing product reports for customers and the organisational KPIs.

Through the case the integration management (objective 2) was assessed to understand how SG processes connected with the rest of the organisational processes. Based on the SrIC analysis of company B it became apparent that SG did not track management of the sustainability information integration process because all the attention was focused exclusively on the KPIs (sustainability analysis objective).

When the researcher proposed to take actions and to address the managerial aspect of the people level, the GMSG persons shifted the responsibility to HR along with the leadership aspects. It seems that SG was adherent to the sustainability analysis objective (KPIs) and left the action management to other groups without providing an effective information mechanism and leadership.

Table 46 describes the management and leadership performance of the sustainability group at the time the case took place. All the tactics and capabilities issues point to the limited management and leadership skills in the area of integration management process and knowledge development. The issues revealed by the case analysis were based on SrIC-in action analysis and SrIC-detailed analysis. Table 46 summarises the researcher's observations using the SrIC analysis flow (read horizontally). The first major column provides analysis of IC in action, and includes hotspots of human and cultural capitals. The second major column includes tactics and capabilities, and each SrIC-in action hotspot is connected to the related tactics and capabilities that require enhancement. After the analysis of the SrIC capital the researcher provided suggestions (see Appendix 4 for more details) for the SG of company B. In Table 46 below, the letters of SrIC-in action hotspots relate to the letters of slots of Table 36.

Table 36 shows the connections between the leadership capabilities and the structural, information, and group tactics. These connections help in identifying key points that can potentially improve the SrIC. The analysis of company B allowed to identify five hotspots for intervention; each point is related to a leadership aspect and a blend of tactics.

The continuous improvement (objective 3) is tied to the management of knowledge development mainly gained during the application of the LCM factors.

Based on the analysis of the sustainability-related organisational processes of company B across three organisational levels described in the Appendix 4, it can be concluded that the information has a perpetual spiral flow. This flow starts with setting the strategy at the strategy level, integration management at the organisational processes level across the various organisational groups and implementation at the operations level. Then, the implementation leads (through reporting flow from the operational level to the processes and strategic levels) to adaptation of

the processes and strategies. Knowledge development is a perpetual process where updated data provide updated knowledge that constitutes a knowledge development mechanism.

The nonexistence of knowledge development mechanism in company B was clearly demonstrated when the researcher discussed development of more efficient information systems and collective knowledge infrastructure with participants, the GMSG and CMSG people realised the inefficiency they caused and importance of examples for the knowledge infrastructure.

The researcher believes that objective 3 (continuous improvement) contains objective 1 (sustainability analysis) and 2 (integration management). Using the case of company B, the researcher was able to demonstrate serious gaps in the realisation of objective 2 that do not allow the fulfilment of objective 1 and 3. Intra- and inter-group management tactics and leadership capabilities of SrIC can help them to enhance their performance to fulfil objective 2 and the latter is the major lesson learned from this case.

Moreover, the assessment of sustainability-related intellectual capital is unique in LCM literature. This chapter presented a single case and therefore, it would be difficult to generalise observations, but at the same time this case provides many contributions to knowledge as these factors have not been explored before and could be used as a reference point for future research. Some of the contributions are:

- There are sustainability professionals who do not have the Sustainability-related Human Capital to deliver their tasks successfully.
- The sustainability information infrastructure was not developed and available information/knowledge can fail to reach the people that need it.
- Management of the sustainability group and intra-organisational interrelations structure is important and it is under-performing.
- Knowledge development is a key to unlock better LCM performance.

  The link IC between tactical competences and leadership capabilities is novel and offers utility in assessment of the performance of sustainability management.

Table 46. SrIC analysis summary.

IC in action				Matrix		
Capitals	**Factors**	**Hotspots**		**Tactic factors**	**Slot challenge**	**Capability factors**
Human	Competencies Knowledge in action	a. LSAs capital is weak. *Not helpful to lead SA tasks.*		Infrastructure	LSAs have limited time, knowledge and resources.	Align action with values.
				Collective knowledge	No good management of resources.	Learn from experience.
				Renewal	No process of organisational learning.	
Cultural	Symbolic Vision Interrelations	Intra-SA	b. Leadership gap.	Renewal	No feedback from GFSA to CFSA.	Enlist others in the common vision.
			c. Collaboration gap among LSAs.	Process	LSAs don't have good interaction.	Build trust, facilitate relations.
				Information systems	No regular use of information systems by LSAs.	
		Inter-SA	d. SA and Non-SA different view on sustainability issues.	Focus of action	Non-SA prioritise business cases.	Align action with values.
				Motivation		
				Conductivity	SA does not focus on business cases.	
				Agility		Enlist others in the common vision.
			e. SA should lead/ attract Non-SA on sustainability tasks.	Infrastructure	SA enlisted Non-SA in the matrix.	
				Measures	Need measures to develop cases.	
				Conductivity	SA should change from patrolling to be a collaborator.	Build trust, facilitate relations.

9. Discussion and conclusion

This chapter discusses the analysis, assessing how the research answered the research question and offering new understanding. This research is shown to create new knowledge and confirm some theories and concepts that were known in the literature. The research is shown to add important details to current understanding of lifecycle management and knowledge development.

9.1. Has this research answered the research question?

This research is based on one research question: What are the factors that influence the integration of sustainability aspects in organisational processes?

From the beginning the researcher adopted the notion that an organisation was a complex system with many interrelated mechanisms, and these mechanisms process information to make decisions that bring better results for the organisation. The research question considers information that is integrated into the information processing and influences decision-making. The academic literature provided limited information about the process, while grey literature discussed that this integration was problematic. Taking this complexity into consideration, the researcher decided to explore the LCM that was 'advertised' by the sustainability specialists as a promising but not well-researched concept. Through his study the researcher showed that LCM was a promising add-on mechanism in the organisational system that allowed the inclusion of sustainability-related information in the organisational processes.

By understanding the way the organisational system functions, the researcher adopted three organisational levels and studied different processes that take place at these levels. This helped the researcher to offer eight LCM factors that appear across all three organisational levels. To narrow down the applicability of these eight LCM factors the researcher identified three LCM objectives that were linked with proposed LCM factors. To aid the analysis of each objective the researcher developed a set of concepts for each objective that appeared in almost all cases.

Figure 53. Strategy in answering the research question.

Research philosophy states that it is possible to identify an aspect of reality, but not the complete reality. Following that, this research cannot answer the question completely, but can provide new insight into the subject based on four main decisions the researcher made while implementing this work.

Through this study the list of contributions is not the same as the list of ideas. The contribution came from the data and some of the ideas were cause of the data (actual and literature analysis), but they were not in the data. Table 47 describes the list of ideas that emerged from the data and helped the researcher. This helped understand this research because many ideas were generated and used in different ways and decided to make this Table and offer it to the reader in case it might be helpful.

The initial idea was to explore LCM as business method to integrate sustainability, however, the data exploration took me to many different directions with a drive to develop an LCM conceptual framework. The use of the three organisational levels as a concept or the integration of the 3Ps layers to develop a sustainability analysis framework or the use of IC in the context of LCM are some of the different directions.

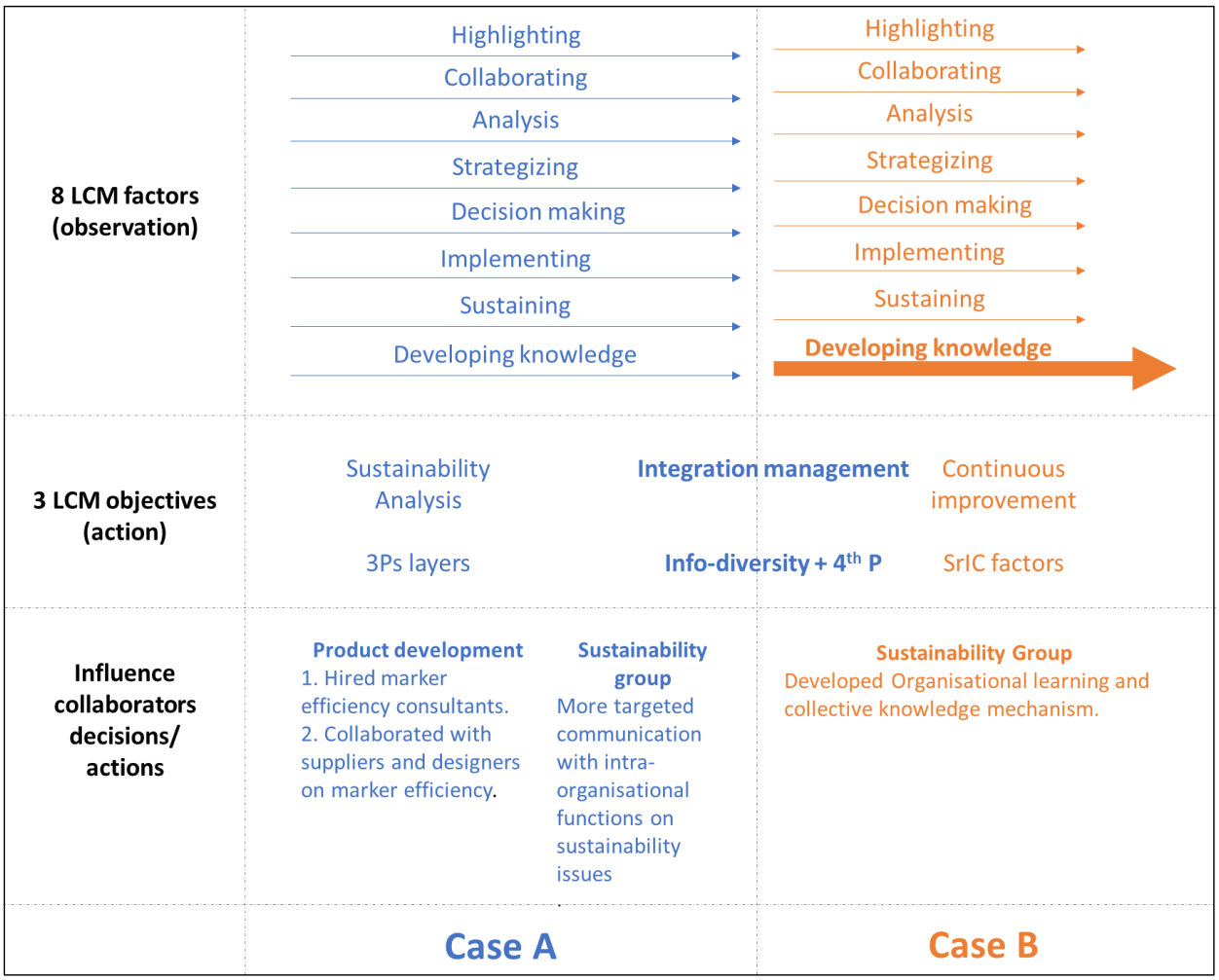
Table 47. Contribution of ideas.

	Concept *an abstract idea that attempts to describe a phenomenon.*	Framework *a system of rules, ideas, or beliefs that is used to plan or make a decision.*	Conceptual framework *A theoretical structure of assumptions, principles, and rules that holds together the ideas comprising a broad concept or support research.*	Method a systematic and logical approach to discovering how things work.
LCM	√		√	√
3 org. levels	√			
LCM factors (list)	√			
LCM elements (list)			√	
Info-diversity			√	
3Ps		√		
Info-complexity			√	
2LCs (product and org.)	√			
Info-cycle			√	
DIKA	√			
Knowing-doing gap	√			
KD loop			√	
SrIC			√	
SrIC-in action analysis		√		
SrIC-detailed analysis		√	√	

9.2 Active engagement summary

In both cases the researcher was invited to conduct research while being actively involved and being given a role as a member of the project team. The engagement pattern was similar in both cases. In the beginning, the researcher presented his concepts related to the three LCM objectives. Then, the sustainability groups recognised the potential of the researcher's concepts and agreed to collaborate. The researcher, with the assistance of the collaborators on data collection, conducted the analysis. Finally the results were presented and discussed, and along with the concepts from the research, these helped guide the collaborators to make decisions. In parallel, the researcher was collecting project observation related data to analyse the presence of the eight LCM factors.

Table 48. Active engagement across case A and B.



In case A, the researcher was invited (by the Head of CSR) to conduct sustainability analysis and integration management. The researcher from the beginning presented the 3Ps approach and the info-complexity concept that were accepted by the collaborators, and also drove the analysis. As a result, the researcher influenced the sustainability team to take actions based on the concepts provided by the researcher. For example, based on the understanding of the 3Ps and info-diversity the sustainability team and related functions were able to decide which SA tool might better inform their decisions. They stated that they were not able to see this before the researcher introduced these concepts.

The observational analysis of case A guided the researcher to focus on Developing Knowledge and develop an intellectual capital concept that was then used in case B.

In case B, the researcher was invited by the sustainability strategist to provide insights on how to enhance the effectiveness of their sustainability strategy with the agreement that if the concept described provide a promising insight, they would set up a joint project. The concept was widely accepted by the sustainability team and they established the project. The SrIC tool was characterized as a complex tool, nevertheless, the discussions triggered during the interviews helped the participants realise the importance of the sustainability aspects and this led to various decisions made on the integration management that would not have taken place if the team would not use the conceptual framework.

This research is argued to be a typical example of how action research can contribute to observation research and then how observation research can contribute to action research.

9.3. Contributions to knowledge

In this section, the researcher presents his contributions to knowledge on LCM. The aim of this research was to help corporate sustainability practice and to contribute to scientific research. This research enhanced the knowledge on four key areas for LCM:

- LCM literature

  As described in Chapter 2 various LCM researchers [such as Poikkimaki (2006), Jensen and Remmen (2006), Remmen and Tharane (2007) Nillson et al. (2014), and Sonnemann et al. (2015)] stated that LCM is vaguely defined and there is an absence of LCM cases analysis in the literature. This research conducted analysis at the level of definitions, descriptions, concepts and cases in section 2.2.1.1. while the closest researchers - Sauer et al. (2003), Poikkimaki (2006) and Sonnemann et al. (2015) – have only provided a limited list of definitions without providing analysis. The researcher through his analysis in this study:

  - Introduces the information aspect of LCM and does not focuses on tools or address activities of actors. Information is argued to be the ‘glue’ that connects the various aspects that the current definitions want to address.

- Uses information integration as a core aspect of LCM and showed how to link the different aspects of the various definitions in the literature.
- Provides a conceptual framework that maps the different LCM concepts and provides a structure for LCM. The provided framework introduces the four elements of LCM. Among the elements, the VC standpoint element differentiates the way LCM is approached. Nevertheless, these two VC standpoints are interrelated and together provide a more complete view of LCM.
- Through the analysis of LCM cases that has not been appeared in the LCM literature before the factors that influence/support that application of LCM were described. The knowledge of the factors can help a sustainability professional that wants to integrate sustainability-related information to organisational processes by managing the factors that structure/support the application of LCM.

- Strategic management levels adoption in LCM

  The researcher highlighted the two lifecycles (LCs) that LCM has to address. The product LC where most of the current LCM researchers' attention is focused (as explained in section 4.3.1.) and the organisational processes LC where there is limited attention (as described in section 2.2.3.). Within the LCM literature only Labuschagne and Brent (2005) mentions the strategic management gap. In corporate sustainability literature as mentioned in the introduction addresses the problematic adoption of sustainability across strategic levels. The separation of the two LCs offers a new way to draw the line between the product LC-analysis and the integration of information in organisational processes. Through further analysis of the two LCs the researcher made the following additions:

  - Highlighted the variability of sustainability-related information across the value chain at the product, processes and place layers. In the LCM literature the product layer monopolizes the analysis in most of the LCM cases. The separation of the value chain into these three layers indicates the sustainability-related information diversity that the organisational processes need to consider.

- Highlighted the human layer at the organisational processes level. The LCM literature mentions the informing decision-making part and the variability of functions to be informed. This research has shown the complexity of sustainability-related information integration in the organisational processes by demonstrating the division of information flows towards different functions with different value chain stages and layers information needs and different way of presenting the information depending on the receiver's needs.

- Knowledge development factor importance for LCM

  The importance of knowledge development for effective application of LCM is first described in this research. Poikkimaki (2006) conducted research in knowledge conversion process by adopting the SECI model of Nonaka and Takeuchi (1995) in an LCM case observation. However, knowledge development has not been addressed in LCM before. This research analyses a core factor that influences the effective application of LCM.

- Intellectual capital in LCM

  This research introduces the intellectual capital concept into LCM for the first time and developed the SrIC framework to help sustainability managers map and improve the integration of sustainability related information in organisational processes.

9.4. Yet more ideas emerging from the research

In this section, the researcher discusses a range of ideas that are emerging from the synthesis of this study.

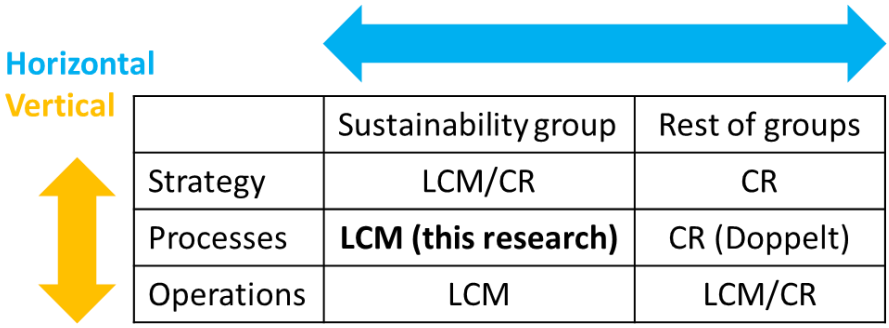
The LCM definitions in the literature were very vague, and most case studies were devoted to the sustainability analysis objective and highlighted interesting aspects of analysis' results to influence decision-making (processes) and strategy development with limited references to the integration. This disregard of integration was affected by the highly influential LCA cohort of the LCM community. The researcher found it interesting that the first research group that focused on LCM (Linnanen et al., 1995) saw LCM as not merely an analysis concept, but as a concept that also manages and leads the analysis of information and helps to integrate knowledge into the

organisational processes and subsequently to merge sustainability with the culture of the company. Unfortunately, the LCM cohort did not pay attention to Linnanen et al. (1995) and their suggestions regarding the management aspect of LCM and so they focused mostly on the analysis aspect. The LCM literature analysis showed that the majority of LCM researchers had a holistic VC standpoint, while Linnanen et al. (1995) also focused on VC actor standpoint.

Concerning the fit of LCM in the organisation, the researcher explored three key concepts from the literature that were not explored deeply.

1. The vertical distinction of organisational levels as described in Figure 1 by Labuschagne and Brent (2005) in the context of corporate sustainability.
2. The horizontal difference between sustainability and other organisational groups, taken from intra-organisational cooperation as described by Jensen and Remmen (2006).
3. The 'advertised' potential of LCM as a business strategy for corporate sustainability (Remmen et al., 2007).

Figure 54 clarifies how the researcher sees the fit of corporate responsibility (CR) and LCM using the vertical and horizontal analysis filters. The researcher observed that on the horizontal dimension LCM focuses more on the sustainability group providing information to the rest of the groups while CR focuses on influencing the rest of the groups to consider sustainability. On the vertical dimension, the researcher identified two approaches that address corporate sustainability from the literature mentioning vertical distinction of organisational levels. CR has a top-down approach while LCM has a bottom-up approach. For example, considering the sustainable apparel coalition (SAC) mentioned in case A, the decision of brand A to join SAC was a strategic decision highlighting to the non-SG the need to consider sustainability and deliver products with acceptable sustainability performance (top-down CR approach). Whereas the action of brand A SG on the formation of the brand's sustainable apparel programme (SAP) had a bottom-up approach. This does not imply that one approach is better, but considering the company B case it is clear that these approaches are synergistic and support each other. This synergy is pictured also in Figure 54 that brings CR and LCM together; at the strategy level CR guides LCM, and at the operations level LCM provides performance analysis for CR.



	Sustainability group	Rest of groups
Strategy	LCM/CR	CR
Processes	**LCM (this research)**	CR (Doppelt)
Operations	LCM	LCM/CR

Figure 54. The fit of CR and LCM with the organisational structure.

The top-down CR approach shows influence from the strategy level onto the operational results without providing emphasis at the processes level for the sustainability group. This approach is addressed in the works of Epstein (1996), Grayson (2012), McElroy and van Engelen (2013), Epstein and Buhovac (2014), and van Tulder et al. (2014). In their discussion of horizontal complexity, the authors take top-down approach, putting emphasis on influencing the decision-making groups than organising the sustainability group to influence the organisation.

Doppelt's (2010) work on change management for sustainability is a noteworthy exception in the sustainability literature. Doppelt (2010) is the only author who focused on the organisational processes. Additionally, he discussed change management for sustainability while mentioning change management factors that are linked with IC. It is very interesting to see how his seven points for change fit with this research.

- Change from patriarchal thinking (top-down) to middle/low up. This research focused on this factor in addressing the organisational levels issues and the researcher adopted LCM as a promising bottom-up framework towards sustainability.
- Create an effective transition team. This factor relates to the LCM collaboration factor, and it was also mentioned by interviewees in case B and was linked to enabling action capability and structural tactics.
- Craft an ideas vision and guiding principles. This factor relates to the LCM strategy factor and was addressed by the SrIC analysis framework (model the way and inspire a shared vision capabilities).

- Engage with source-based operations and governance change strategies. This was addressed by the capability to align action with values and the suggestion to develop business cases.
- Develop constant information flows. This relates to the LCM sustainment factor and was also addressed by the information tactics.
- Develop feedback loops and organisational learning. This relates to the knowledge development LCM factor and was also highlighted by the renewal tactic.
- Align system, structures, policies and procedures with sustainability. This was highlighted through the align action with values capability and the agility-packaging tactic.

From the viewpoint of this research it is interesting that Doppelt's (2010) seven points of change management for sustainability that were a result of a long study that considered many more studies, match the frameworks developed by the researcher.

After considering Doppelt (2010), the researcher believes that this research can also be viewed as change management focused and would benefit from analysis using Change Management concepts and frameworks.

The second approach to LCM is bottom-up, which focuses more on the operational level analysis: this approach looks at the results that influence the decisions at the organisational process level and subsequently the strategy. On the horizontal analysis, LCM tends to provide tangible sustainability-related information usually controlled by the sustainability group or sustainability person of each group, who integrate this information into the decision-making.

The researcher chose to explore an LCM approach that focuses on the organisational processes level, but this limited the direct contact with the strategy level of the rest of the groups. Nevertheless, this decision allowed the researcher to explore the integration process in action and to identify the factors.

The researcher found useful the conceptual description of the organisation provided by Henry Mintzberg (1979), see Figure 55, was observed to comply with the fit of the sustainability group in the organisational structure of the companies in cases A and B. The sustainability group is often

not a core group; where the technostructure is covered by the sustainability analysis objective of LCM, while support staff is addressed by the integration management and continuous improvement objectives.

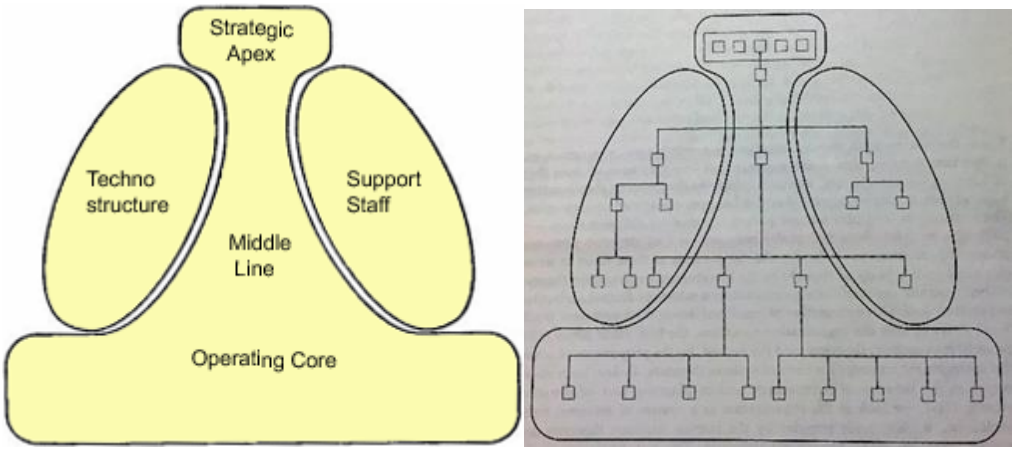


Figure 55. Mintzberg model (left) and authority levels (right) (Mintzberg, 1979).

The literature does not give a clear answer to the question how LCM as a conceptual framework can help a company to become more sustainable. Various authors make statements about LCM as an umbrella framework, or LCM as a toolbox, and different ambition levels at each company. From the researchers point of view, many of the authors writing about LCM are more interested in the LCA part than the LCM conceptual framework. For this reason, the LCM conceptual framework is considered as a tool and therefore, it is more focused on assessment than management. The researcher believes that LCM is about integrating the sustainability information in the organisational processes to influence the decisions made.

People layer presents certain difficulties for the sustainability manager because of different philosophical views of development held by the parties (i.e. sustainability professionals and the rest of the organisation). Sustainability professionals are trained to develop a more sustainable planet and through LCM they try to communicate this information. However, the people who are influencing their priorities are driven by business development. Therefore, sustainability information that needs to be integrated into the organisational decision-making has to compete with other information and its integration success depends on the level of importance for business development. To compete at this level, the sustainability managers have to be

competent in developing sustainable business cases, as for example, the SG Head in case A, who provided both information and solutions. The SG Head seems an exemption due to his education.

Developing knowledge is another factor that is very important for LCM. As it was explained by Schimpf and Roth (2002) in Chapter 6, a large portion of knowledge in use already exists, while a smaller portion is new knowledge. The researcher demonstrated that knowledge management (KM) is the most important part for LCM, where KM is the most efficient use of existing knowledge and the capture of new knowledge that leads future development. Case B showed that even in the situation where knowledge is available within the organisation, its inefficient management could be equivalent to an absence of knowledge.

9.5. Quality and rigour

The research method chapter closes with Tables 12 and 13 introducing the quality and rigour factors discussed through this research. In this section the researcher will address credibility, transferability, dependability, confirmability and quality factors specific for action research.

9.5.1. Credibility

According to Lincoln and Gupta (1985), credibility is very important for trustworthiness, and links with the question 'how consistent to reality are the findings' (Merriam, 1998). Shenton (2004) provides the credibility factors discussed below.

Adoption of appropriate, well-recognized research methods

The research method decision-making process was strongly influenced by the framework provided in Table 9. This process helped to identify the research design that fitted research question. The researcher chose action research and engaged scholarship to address the research question.

There is very limited research on the sustainability aspects of LCM. However, the researcher identified two works where research focus overlapped with this research in certain aspects: Poikkimaki (2006) and Nilsson-Linden (2014). Both authors followed a case study design. The

researcher followed an AR/ES method with much better access to data, and this helped to have a more detailed approach to the subject, and this is reflected in the insights of this study.

Development of early familiarity with the culture of participating organisations

As stated by (Silverman, 2001) and (Pitts, 1994) the researcher needs to establish a trusted relation with participants and at the same time maintain objectivity.

In both cases the researcher established a relationship with research partners at a very early stage, which allowed to receive an access to internal company documents that helped in understanding of the company's culture, and helped to facilitate collaboration with representatives of organisations. Signed confidentiality forms helped a lot in building trust of the participants.

Triangulation via the use of different methods, different types of informants and different sites

Triangulation was used in both cases and applied through documents analysis, individual interviews, group interviews, and focus groups. Moreover, in case B, an independent observer was used to enhance credibility.

As to the types of informants, in case A the researcher involved participants from different groups, but at the same organisational level. While in B case participants from various groups and all three organisational levels participated in the interviews and focus groups. Site triangulation applied only in case B, where the participants represented various sites from the same country.

Tactics to help ensure honesty in informants

The participation of respondents was voluntary. For example, in case A that the project took place when the participants saw the need for it, after cancelling it during the first time. In case B, participants were invited to participate. This allowed to include the ones who genuinely were willing to participate and were prepared to offer data. This resulted in involving participants who contributed interesting ideas and shared their own experience.

Iterative questioning in data collection dialogues

The use of semi-structured interviews helped a lot as the researcher was able to focus on specific matters and answers, and had an opportunity to discuss the subject multiple times and to ask the participants additional questions during the data analysis process.

Negative case analysis

In some cases, the data did not fit well with the framework based on literature sources and the researcher continued to perfect the concept development until all the framework was able to explain all data.

Debriefing sessions between researcher and superiors

The researcher had frequent meetings with the academic supervisor and the industrial leaders to discuss the process.

Peer scrutiny of the project

Early in the process the researcher seeked feedback from the colleagues regarding the theoretical aspects of the thesis as well as the results during research conferences on the analysis and integration objectives.

Use of "reflective commentary"

A key part of the project was the 'progressive subjectivity' of the researcher. The initial ideas of the researcher were based on the integration of LC-tools to provide a better quality of information to inform decisions. While the research was progressing the researcher realised that the main problem was not an engineering aspect of LC-tools integration, but an organisational management problem.

Description of background, qualifications and experience of the researcher

The researcher has a background in sustainability studies and a five-year degree in Environmental and Natural Resources Management from the University of Ioannina. His interest to the subject was connected to the background, and because of that the researcher was interested in exploring why companies were not sustainable. To find answer to this question, the researcher joined the MSc course in Environmental Management for Business offered by Cranfield University. After

completing the course, the researcher felt that he did not find an answer to that question and decided to continue to a PhD and to conduct research on this topic.

Member checks of data collected and interpretations/theories are formed.

The researcher asked a colleague to check the accuracy of transcripts and then asked the participants to approve the transcripts accuracy. Moreoever, interesting aspects explored during first interviews were raised again in the subsequent interviewers.

Thick description of phenomenon under scrutiny

The interviewees were asked to provide examples from their everyday life to accompany their statements. This has allowed to achieve triangulation of results.

Examination of previous research to frame findings

As discussed earlier, there is limited research on this topic. Nevertheless, the researcher tried to make connections between his results and the existing body of knowledge and previous research on LCM and other topics.

9.5.2. Transferability

Thransferability is focused on the understanding of the study background to ensure that transfer to another context is valid. As mentioned in Chapter 3, action research focuses on the mechanism while disregarding the context. The researcher is not stating that the results are fully transferable. Nevertheless, some of the results could be transferable because sustainability group is not a unique group within the organisation.

9.5.3. Dependability

The qualitative research is facing the changing nature of the addressed phenomena, which challenges reliability of the result. Lincoln and Gupta (1985) proposed the use of overlapping methods to overcome this issue. For this study, the methodological part can be repeated, the data collection methods are repeatable, and the researcher can raise similar core questions, but it is possible that respondents will bring up different issues because of the change in the context.

9.5.4. Confirmability

Confirmability ensures that results come from the participants and not preferences of the researcher (Miles and Huberman, 1994). Shenton (2004) suggested five factors of confirmability:

- Triangulation helps to reduce the effect of investigator's potential bias and it was applied in this study.
- Admission of researcher's beliefs and assumptions. The researcher's beliefs mentioned in Chapters 4 and 7 were accepted by research partners.
- Recognition of limitations in study's methods and their potential effects. The study's limitations were mentioned through the study.
- In-depth methodological description to allow the integrity of research results to be scrutinised. The researcher provided methodological descriptions in Chapter 3 and further discussed them in Chapter 5 and 8.
- Use of diagrams to demonstrate "audit trail". Many diagrams were used to describe the decisions made and research processes across the study.

9.5.5. Quality factors specific for action research

The factors mentioned above are focused on methods appropriate to case study without considering the unique aspects of action research. Reason (2006) provided a list of quality and rigour factors that were addressed throughout the research (Appendix 11).

9.6. Further research

Any research can be continued because there are always unanswered questions. Therefore, any completed research initiates the beginning of the next cycle of analysis, and this is perfectly reflected in the ideas of knowledge development process, since contribution to knowledge is a never-ending process. The researcher decided to share some of the ideas that could be further developed during follow-up research:

- To analyse various literature (including CR, LCM, EMS, etc.) focusing on corporate sustainability to identify differences, overlaps, gaps so it can be understood how all these concepts fit under the corporate sustainability domain.
- To conduct more case studies in various types of organisations with different:
    - Product types and product LC characteristics;
    - Organisational structure;
    - Countries, and
    - Different actors of the VC.

  To explore the aspects that work and fail to work in specific organisations.
- To extend the research to the inter-organisational part of the organisation considering the relational-IC.
- To explore different management strategies that a sustainability group can follow:
    - For intra-group management
    - For intra-organisational management
    - For inter-organisational management
- To analyse different business development strategies of sustainability group.
- To develop a sustainability-related quality management system based on KM and IC.
- To explore the Lorenz attractor phenomenon in corporate sustainability. This idea came from the way corporate sustainability strategy was implemented across the organisational levels and groups and McElroy and van Engelen (2013) statement that corporate sustainability management is a double-loop cycle (∞: Plan→Assess→Act). Morgan (2006) who described certain aspects of organisational management used the Lorenz attractor (Figure 56) as an example of a system that combines order and disorder. When the data are plotted in three-dimensions, the pattern of the data is never repeated in the same way.

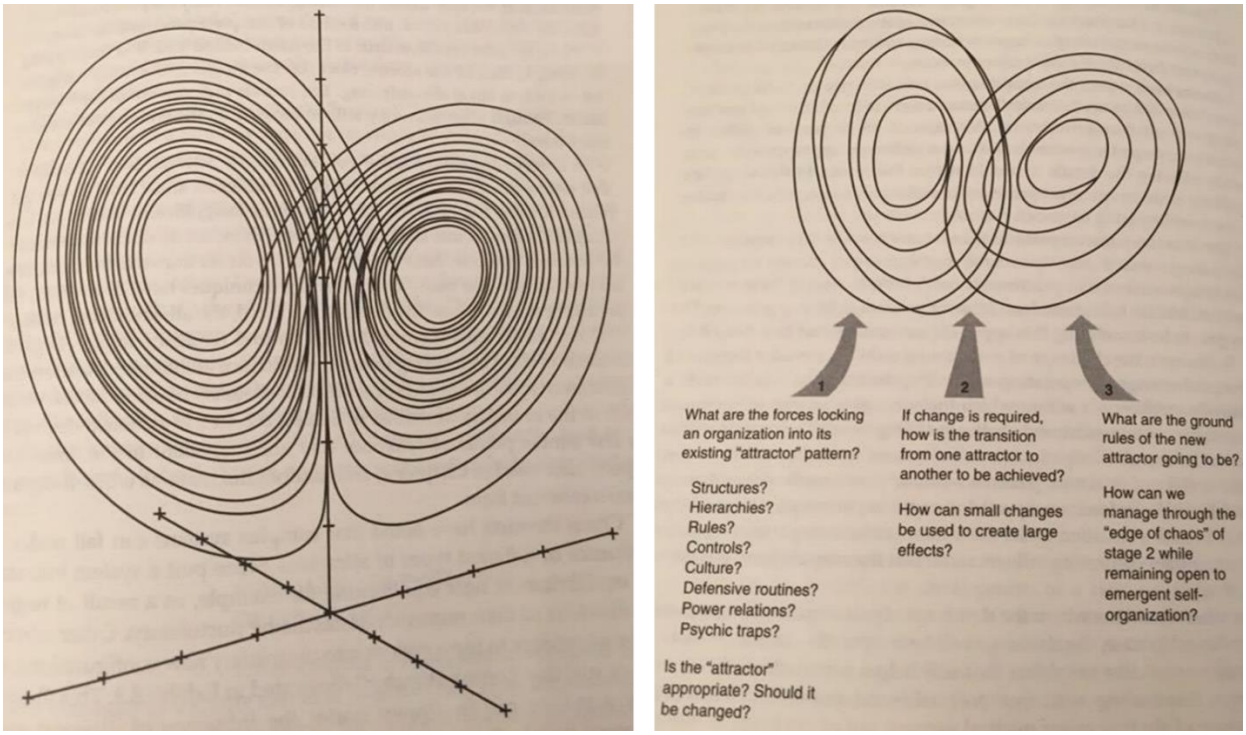


Figure 56. The Lorenz attractor patterns and organisational change (Morgan, 2006).

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Appendices

Appendix 1 – LCM definitions list

Table 49. LCM definitions identified in the literature.

Authors	LCM definition
Linnanen et al. (1995)	*'the integration of environmental issues into the company's decision-making processes, consideration of the environmental effect over the product lifecycle necessitated by the product stewardship and the importance of cultural change in environmental management processes.'*
Cramer (1996)	*'the integrated management of a supply chain in terms of the environmentally, socially and economically responsible management of the production, consumption, distribution and ultimate disposal of a product.'*
Environment Canada (1997)	*'an integrated approach to minimising environmental burdens throughout the lifecycle of a product, system or service.'*
Fava (1997)	*'the linkage between lifecycle environmental criteria and an organisation 's strategies and plans to achieve business benefits.'*
Finkbeiner et al. (1998)	*'A comprehensive approach towards product and origination related environmental management tools that follow a lifecycle perspective.'*
Westkamper et al. (2001)	*'LCM organises the interaction of the lifecycle partners to achieve the maximum benefit from each technical product.'*
Weidema (2000)	*'a management paradigm that takes optimisation of the product chain as its fundamental viewpoint. … a continuous, integrated optimisation of the economic, technological, and social aspects of products.'*
Pedersen (2001)	*'LCM is business management based on environmental Lifecycle considerations.'*
Saur (2001)	*'a flexible, integrated, framework of concepts, techniques and procedures to address environmental, economic, technological and social aspects of products and organisation s to achieve continuous environmental improvement from a lifecycle perspective.'*
Remmen (2001)	*'the extension of the technical approach towards cleaner products and production though amending stakeholder views, by communication and regulatory tracking.'*
Jensen (2003)	*'a new practical, integrated and systematic approach to minimize the environmental and socio-economic burden associated with a product (goods or service) over its entire lifecycle and value chain.'*
Rebitzer and Hunkeler (2003)	*'Making lifecycle approaches transparent, understandable, operational, and readily applicable in routine decision-making.'*
Hunkeler et al. (2004)	*'an integrated framework of concepts and techniques to address environmental, economic, technological and social aspects of products, services and organisation s.'*
Baumann and Tillman (2004)	*'the managerial practices and organisational arrangements that apply lifecycle thinking. This means that environmental concerns and work are coordinated in the whole lifecycle instead of being independent concerns in each company.'*
Ameri and Dutta (2005)	*'PLM is a knowledge management solution which supports different processes throughout the product lifecycle within the extended enterprise.'*

Rebitzer and Buxmann (2005)	*'aims at expanding the scope of the environmental management system of a company to address the up- and downstream impacts associated with the activities of its suppliers and customers.'*
Jensen and Remmen (2006)	*'the application of lifecycle thinking to modern business practice, with the aim to manage the total lifecycle of an organisation's products and services towards more sustainable consumption and production.'*
Remmen et al. (2007)	*'a product management system aiming to minimize environmental and socioeconomic burdens associated with an organisation 's product or product portfolio during its entire lifecycle and value chain.'*
Remmen and Thrane (2007)	*'a business strategy towards sustainability as well as on the intra- and inter-organisational challenges to industrial organisations. … a business strategy that assists industry to implement sustainability strategies to achieve competitive advantage through process and products innovations.'*
Jorgensen (2008)	*'LCM integrates lifecycle thinking of the organisations' activities across departments and business areas.'*
UNEP/SETAC (2009)	*'a business management approach that can be used by all types of business (and other organisation s) in order to improve their sustainability performance. …, its purpose is to ensure more sustainable value chain management.'*
Finkbeiner (2011)	*'a comprehensive approach towards product and organisation related environmental management tools that follow a lifecycle perspective.'*
Puglieri et al. (2013)	*'a business approach to improve the companies' sustainable performance aiming the long-term value creation in the whole lifecycle.'*
Schmidt (2013)	*'a product management system aiming to minimize environmental and socioeconomic burdens associated with an organisation 's product or product portfolio during its entire lifecycle and value chain.'*
Mastoris et al. (2013)	*'a system that manages sustainability-related information to support decision-making towards more sustainable products from a lifecycle perspective.'*
Gemechu et al. (2015)	*'an approach to help companies set up initiatives, to achieve environmental, economic and social benefits at the same time through implementing a step-by-step quality management tool.'*

Appendix 2 – LCM descriptions list

Table 50. LCM descriptions in the literature.

Authors	LCM description
OECD (1994)	*'LCM (sometimes known as the cradle to cradle approach), is increasingly used by environmental policy makers to address product overall environmental impacts. This holistic approach is known as lifecycle analysis or assessment. For producers, lifecycle analysis provides a management tool analogous to total quality management for folding environmental considerations into the entire design of a product and its processes, seeking to avoid the traditional treatment of environmental problems as side-effects which require additional treatment outside the product and process design. It shifts the attention from end-of-pipe solutions and looking for technological fixes to minimisation of environmental problems; from cure to prevention. LCA generates the information necessary for a producer to accept responsibility for the social (i.e. environmental) costs of production and consumption of their products'*
Linnanen et al. (1995)	*'Lifecycle management consists of three views: (1) the management view – integrating environmental issues into the decision-making of the company; (2) the engineering view – optimizing the environmental impact caused by the product during its lifecycle; and (3) the development view – creating a new organisational culture.'*
Environment Canada (1997)	*'Lifecycle management is to establish a thorough knowledge of the environmental burdens of the products manufactured by the company and use this for improvement actions. The process includes employees at most levels of the company and starts with an identification of all unit processes at the production site and an analysis of the related in- and outputs. In the next step up- and downstream processes are examined. The results from the process can be used to establish an LCA, but it is more important that the results are used to minimize the environmental burdens. This is done by using a set of tools tailored to meet the needs of a given company, e.g. design for the environment, pollution prevention strategies, waste audits, green procurement etc.'*
Weidema (2000)	*'As a management paradigm, it includes the concepts, tools and procedures to reach this objective. The original inspiration behind LCM comes from Product Lifecycle Assessment (LCA), a technique to assess the environmental impacts related to a product with the aim of minimising these impacts seen over the entire lifecycle of the product, from raw material extraction to final disposal. In LCM, the lifecycle concept is expanded to other areas of concern, notably management of economic costs and quality.'*
Westkamper et al. (2001)	*'The goal of this approach is to protect resources and maximize the effectiveness during usage by means of Lifecycle Assessment, Product Data Management, Technical Support and last but not least by Lifecycle Costing. … Lifecycle management" organizes the interaction of the lifecycle partners to achieve the maximum benefit from each technical product.'*
Klopffer and Heinrich (2002)	*'LCM is a concept rather than a method or a tool (such as Lifecycle Assessment (LCA), Lifecycle Costing (LCC) and others) and, as such, has obtained much attention. The relation between the concept and the tools, however, is not well established and deserves a thorough and critical discussion. … The concept of LCM is broader than LCA or LCC, aims at sustainable industrial development (in this context the 'triple bottom line' has been mentioned frequently) and uses a 'tool box' rather than one well-defined method. At a closer look, however, it seems that each group uses its own approach and mixture of methods and it is not always clear how well the methods taken out of the*

	tool box are tuned in or fit together. The most serious problem is that different lifecycle tools have to use the same system boundaries in order to provide compatible results.'
Heiskanen (2002)	*'LCA-based ideas and tools can be viewed as emerging institutional logics of their own. While LCA makes use of many scientific models and principles, it is more a form of accounting than an empirical, observational science. Thus, the lifecycle approach implies a kind of "social planner's view' on environmental issues, rather than the minimization of a company's direct environmental liabilities.'*
Jensen (2003)	*'LCM will promote a sustainable development by linking environmental improvements with economic efficiency and implementation will be useful for companies wanting to increase their resource productivity and be proactive and ready for the future challenges from society, legislations and consumers.'*
Rebitzer and Hunkeler (2003)	*'Within the area of product-focused environmental management, lifecycle management (LCM), attempts to put sustainable development into practice. LCM, with its toolbox and decision-oriented goals, seeks to render sustainability accessible, quantifiable, and operational. Therefore, the aforementioned three pillars of sustainable development can also be found in LCM.'*
Hunkeler and Rebitzer (2003)	*'LCM, therefore, aims at integrating environmental concerns into industrial and business operations by considering off-site, or supply chain, impacts and costs. LCM seeks to increase the competitiveness of new, and existing, products by examining advantages, and business risks, associated with the environmental and social aspects of a product, throughout its lifecycle. Therefore, LCM can be seen as a means of putting sustainable development to work within a firm, given its temporal and financial constraints. the LCM toolbox, of which LCC is an important part, will be required in new product development, product introduction, supply chain negotiation, environmental product declarations, and cost reduction. A full accounting of the indirect costs which often dominate businesses is good for the bottom line, provides competitive advantages, lowers credit risks, and enhances image.'*
Saur et al. (2003)	*'LCM is not a single tool or methodology but a flexible integrated management framework of concepts, techniques and procedures incorporating environmental, economic, and social aspects of products, processes and organisations. It is voluntary and can be gradually adapted to the specific needs and characteristics of individual organisations. … 'LCM is the extension of the technical approach towards cleaner products and production through amending stakeholder views, by communication and regulatory tracking. … LCM is a flexible integrated framework of concepts, techniques and procedures to address environmental, economic, technological and social aspects of products and organisation s to achieve continuous environmental improvement from a lifecycle perspective. LCM is also described as a management pattern that can be applied on a voluntary basis and can be adapted to the specific needs and characteristics of individual organisation s. '*
Hunkeler et al. (2004)	*'LCM provides businesses with indicators for decision-making. … LCM concept is an integrated system for improving operations, products, and services that ensures information and decisions from a life-cycle perspective and quite often, is seen to improve decision-making by placing better information in front of decision-makers. … LCM enables firm to gain and maintain competitive advantages and cost savings through cooperation with business partners. … LCM extends actions beyond the organisation, so that firms in the supply chain are linked and able to make comprehensive, product-oriented environmental improvements. … LCM provides*

	relative, streamlined comparisons of alternative choices and outputs with results in a concise form suitable for mid- and top-level corporate decision-makers. … LCM permits key information to be readily integrated into operational decision-making to ensure consideration of issues beyond immediate financial concerns and beyond the organisation's gates. … LCM approach organisations may modify existing tools, techniques, and decision processes to help them effectively link the performance of their organisation (e.g. customer satisfaction) with environmental performance. …. LCM is a business concept for environmental management. … LCM is a practical and integrated approach to minimise the environmental burdens associated with a product over its lifecycle. It is a concept that may be useful in moving towards sustainable development and a means of linking environmental improvement with economic efficiency. … LCM's toolbox makes use of existing environmental tools and management systems, which may include national or international voluntary standards and validated indicators or metrics. … LCM supports the business assimilation of IPP, eco-labelling, DfE, green procurement, and other product or market related business or government initiatives. … LCM engages all divisions of an organisation and extends perspectives beyond the firm's gates, it addresses these drivers in a proactive manner, tackling each as an opportunity for added value and business excellence. … Key components of LCM: is based on life-cycle thinking, has the goal to optimise the whole lifecycle, includes all aspects of improvement, is seen as a multi-criteria approach, includes supply-chain partners, includes several functions within the firm (e.g. design, purchasing, manufacturing, research and development, is pragmatic. … LCM is an overall business strategy and is supported by different management systems and tools such as ISO 9001, SU, LCA and eco-design. … Full implementation of LCM at company level means that the company has generated a sufficient overview of environmental causes and effects throughout the lifecycle of its major products, processes, operations, and other activities, and has a continuous implementation of the overview in all relevant business decisions. The company has generated the overview by carrying out LCAs for its major products and other activities, and has applied environmental lifecycle considerations in all major business decisions – from strategic planning, product development, purchase and production to distribution and sales.'
Rebitzer and Buxmann (2005)	*'LCM is based on a perspective that focuses on products and the corresponding processes in addition to facilities and production sites. Therefore, the lifecycle assessment (LCA) methodology plays a central role in implementing LCM. … LCM can be seen as a framework for the implementation of sustainable development on the business level. … It is a concept, which may be useful in moving towards sustainable development and a means of linking environmental improvement with economic efficiency. … LCM is applied on a voluntary basis and can be adapted to the specific needs and characteristics of individual organisation s. … LCM facilitates transparent internal and external communication. … LCM's toolbox makes use of existing environmental tools and management systems, which may include national or international voluntary standards and validated indicators or metrics. … LCM supports the business assimilation of integrated product policy, eco-labelling, design for environment, green procurement, and other product or market related business or government initiatives.'*
Ny et al. (2006)	*'LCA often lack a sustainability perspective and bring about difficult trade-offs between specificity and depth on the one hand, and comprehension and applicability on the*

	other. In response, a new field of research and practice, called lifecycle management (LCM), is emerging, in which the focus is shifted toward the relationship between sustainability issues and lifecycle thinking in practice.'
Zbicinski et al. (2006)	*'The job of an LCM is to control the technical and logistical system, and analyse them throughout the lifecycle of the product.'*
Grieves (2006)	*'Product Lifecycle Management (PLM) is an integrated, information-driven approach comprised of people, processes/practices, and technology, to all aspects of a product's life, from its design through manufacture, deployment and maintenance—culminating in the product's removal from service and final disposal. By trading product information for wasted time, energy, and material across the entire organisation and into the supply chain, PLM drives the next generation of lean thinking.'*
Jensen and Remmen (2006)	*'LCM is the application of lifecycle thinking to modern business practice, with the aim to manage the total lifecycle of an organisation's products and services towards more sustainable consumption and production. LCM is about systematic integration product sustainability e.g. in company strategy and planning, product design and development, purchasing decisions and communication programs.'*
Remmen et al. (2007)	*'Organisation s use LCM to support their goals of providing products or services which are as sustainable as possible. Many organisation s have seen this strategy lead to improvements in their image, stakeholder relations, shareholder value, as well as, awareness of and preparedness for changes to their regulatory contexts. LCM is not a single tool or methodology but a management system collecting, structuring and disseminating product-related information from the various programs, concepts and tools incorporating environmental, economic, and social aspects of products, across their lifecycle. The organisation must 'go beyond its facility boundaries' and be willing to expand its scope of collaboration and communication to all stakeholders in its value chain. … Lifecycle Management (LCM) aims to minimize the environmental and socio-economic burdens associated with product or product portfolio throughout its entire lifecycle and value chain. LCM makes lifecycle thinking and product sustainability operational for businesses through continuous improvements of product systems, as well as, supporting business assimilation of, for example, integrated product policies. LCM is for organisation s, which have expressed a wish to produce or trade products, which are as sustainable as feasible, to improve their public image, visibility, general relations with stakeholders, and increase their shareholder value, as well as, awareness of and preparedness for changing regulatory contexts. … LCM can be specifically adapted and gradually introduced, in any organisation , including SMEs. Organisation s may begin with small goals and objectives according to their resources and then get progressively more ambitious over time. To be successful it needs a commitment from top management and the active participation of key employees from relevant departments in the organisation . LCM is a dynamic and voluntary process which is best implemented through a step by step process. Special attention should be given to activities that can secure continuous improvement. Finally, the Plan-Do-Check-Act cycle, in line with international management systems for organisation s, such as ISO 9001 and ISO 14001, is recommended. … LCM is making lifecycle thinking and product sustainability operational for businesses through the continuous improvements of product systems, and LCM supports the business assimilation of policies such as integrated product policies. '*

EPA Victoria (2007)	*'Lifecycle management (LCM) is simply lifecycle thinking in practice. It has been developed as a business approach for managing products and services across the total lifecycle. By learning how to more effectively manage this cycle, a company or organisation can uncover a wealth of business, environmental and social value. Lifecycle management can add value by: improving decision-making, providing a means of integrating environmental improvements with economic benefits, identifying mutual opportunities between companies that interact with the product or service at different stages of the lifecycle, conceptualising and structuring work that may already be happening to improve efficiency and reduce risks, systematically integrating product sustainability in company planning, product design and development, purchasing decisions and communication programs. LCM is all about making more informed business decisions — chances are that lifecycle considerations are already influencing the daily decisions you are making in your business. The LCM framework therefore helps business to analyse and understand the various lifecycle stages of the business, product or service. You can then identify the potential economic, social or environmental risks and opportunities at each stage, and establish proactive systems to pursue the opportunities and manage or minimise the risks.'*
UNEP/SETAC (2009)	*'LCM is a framework to analyse and manage the sustainability performance of goods and services. LCM is a business management approach that can be used by all types of business (and other organisation s) in order to improve their sustainability performance. A method that can be used equally by both large and small firms, its purpose is to ensure more sustainable value chain management. LCM can be used to target, organize, analyse and manage product-related information and activities towards continuous improvement along the product lifecycle. LCM is about making lifecycle thinking and product sustainability operational for businesses that are aiming for continuous improvement. These are businesses that are striving towards reducing their footprints and minimizing their environmental and socio-economic burdens while maximizing economic and social values. … LCM can be used to target, organise, analyse and manage product-related information and activities towards continuous improvement along the product lifecycle. '*
Balkau and Sonnemann (2010)	*'LCM constitutes an approach that clamps partnerships and procedures to minimize impacts in a holistic fashion. LCM helps product chain actors to work both on local and system level improvement because it can more easily address global issues and system dynamics than instruments designed for individual use. … an umbrella framework for combining and applying other management instruments in a more holistic life chain perspective.'*
Palmer et al. (2011)	*'the most crucial point is not to quantify and document the lifecycle impacts of one or several systems through LCA but to find a way through LCM for the different stakeholders involved in the value chain of those systems to understand their shared responsibility and to find improvements through eco-design (and then, later or in parallel, apply LCA). … Putting LCA and LCT into practical application and seeing the results accepted by the different affected stakeholders is the realm of lifecycle management (LCM).'*
Finkbeiner (2011)	*'LCM is in a nutshell about the application of LCA or rather lifecycle thinking (LCT). It is still a relatively young concept in the environmental community with pioneering work done by a Working Group of the Society of Environmental Toxicology and Chemistry (SETAC). … Even though there is definitely still room to improve and expand the implementation of LCA as part of an environmental LCM approach, I believe the time*

	has come to expand the concept to include the other pillars of sustainability in a more explicit way. … The unique feature of LCM is practical solutions for the implementation of lifecycle approaches into strategic and operational decision-making.'
Nilsson-Linden et al. (2014)	*'LCM is typically defined by holistic environmental focus, internal integration, collaboration with external actors and carried out with an abundant LCM-based toolbox.'*
Rebitzer (2015)	*'…lifecycle management is an extremely powerful concept and process and can enable businesses and other organisation s to make sustainability part of "business as usual" and deliver real-world improvements for them and their customers.'*
Sonnemann et al. (2015)	*'LCM is mainly a business management concept for sustainable products that can be applied in the industrial and service sectors with the aim of improving specific goods and services and enhancing the overall sustainability performance of the business and its value chains in general. It makes lifecycle thinking and product sustainability operational for businesses that are ambitious and are committed to reduce their environmental and socio-economic burden, while maximizing economic and social values. … Methods and tools used and the general framework for lifecycle sustainability management covering environmental, social and economic aspects in business practices are discussed in detail. …Companies apply it in a number of different ways in order to achieve the desired outcomes, as far as it relates to their sustainability performance. …The definitions of LCM are thus wide and its concept needs further development. … Companies use LCM to support their goals of providing products that are as sustainable as possible. Companies need to go beyond their organisational boundaries and be willing to expand their scope of collaboration through external communications to all stakeholders of their value chain as it makes them more visible, may improve their public image, improve their relations with stakeholders and may increase their market penetration through mapping their product chains and develop criteria for product enhancement and value creation. … LCM is a dynamic process in which companies may begin applying it with specific goals and objectives depending on the resource they have. …One of the critical reasons for companies to be engaged with LCM practices is their pursuit for continuous improvements, covering economic, environmental and social aspects. '*
Mazijn and Reveret (2015)	*'Lifecycle sustainability assessment (LCSA) contributes to the assessment and lifecycle management (LCM) to the follow-up of exercising due diligence, all within the context of sustainable development.'* "Due diligence" is defined as a "comprehensive, proactive process to identify the actual and potential negative social, environmental and economic impacts of an organisation 's decisions and activities over the entire lifecycle of a project or organisational activity, with the aim of avoiding and mitigating negative impacts" (ISO, 2010).
Rubik (2015)	*'Lifecycle Management (LCM) is an umbrella term denominating a business management concept for sustainable products. It can be applied in the industrial and service sectors with the aim of minimizing environmental, social and economic burdens linked to a company's product, product portfolio and brand during its entire lifecycle to enhance their overall sustainability performance and value chain. Thus LCM facilitates continuous improvements of product/systems in terms of their economic, social and environmental sustainability.'*

Gemechu et al. (2015)	*'LCM has been identified as the way to operationalize sustainability challenges into business practices; however, its implementation faces significant challenges. Setting clear and measureable goals is one of the challenges. The focus of LCM initiatives is different from the usual business strategies, which are mainly focusing on maximizing the profit as the ultimate goal. LCM initiatives have a wider scope in order to have both social and environmental benefits along with maintaining the economic advantages. The divergent priorities between the financial and sustainability focuses are challenging tasks for managers at different organisational level. A successful implementation of LCM then needs a full integration across the organisation.'*

Appendix 3 - LCM concepts

There is limited literature focused on conceptual approaches to LCM. Therefore, in the following section the researcher will describe key readings on the topic, approaching LCM from different angles. These readings were selected because they offered a conceptual approach on LCM. The researcher divided all concepts into main and supportive. The main concepts address all elements of the analysis, while supportive concepts address only some of them.

Main concepts

Linnanen et al. (1995)

Linnanen et al. (1995) is the first research team that suggest a conceptual framework for LCM. According to the authors, LCM can be analysed from three different perspectives: management, engineering, and leadership.

From the engineering perspective, LCM focuses on the optimisation of environmental impacts. Moreover, the product's lifecycle is the focal point from the engineering perspective. The aim of engineering perspective is to provide information (mainly from LCA) to improve decisions at the product level, to extend product's lifecycle, and to improve materials selection, manufacturing processes, and design decisions. Lowering the environmental impact of logistics and adopting aspects of the circular value chain are another aspects of the engineering view.

From the management perspective, LCM is focused on the integration of environmental issues in corporate decision-making. The authors highlighted the market orientation of environmental management that LCM should have by aiming for eco-efficiency. The authors put emphasis on intra-organisational cooperation to solve environmental problems while maintaining market orientation, and on inter-organisational cooperation across the value chain and industry-wide coordination to impose stewardship programs.

From the leadership perspective, LCM aims to create a new organisational culture that supports the integration of environmental aspects in decision-making. This view promotes a new management paradigm where environmental issues are part of the business processes. However, the new paradigm requires new development concepts and the right attitude, that can be gradually developed as described in Figure 57.

Figure 57. Environmentally oriented change of organisational culture (Linnanen et al., 1995).

From the researcher's point of view, the management perspective focuses on synchronising the environmental aspects of the business processes, while the engineering view is necessary to provide the information and knowledge to designers, to help decision-making process and implementation of the change, at the same time the leadership view looks at creation of the culture to support management and engineering part.

Westkamper et al. (2001)

Westkamper (2001) looked at the information aspect of LCM and product lifecycle management (PLM) systems. However, their work focuses on improving the product design, manufacturing, and lifecycle activities by reducing the use of resources and maximising effectiveness across the product lifecycle. The authors perceive the concept of LCM in organising the interaction of the value chain actors', tapping into the knowledge of other parties, minimising risks, and maximising results. According to their approach, LCM has four layers, namely design for lifecycle, life time evaluation, life time management and product cycle management (Figure 58).

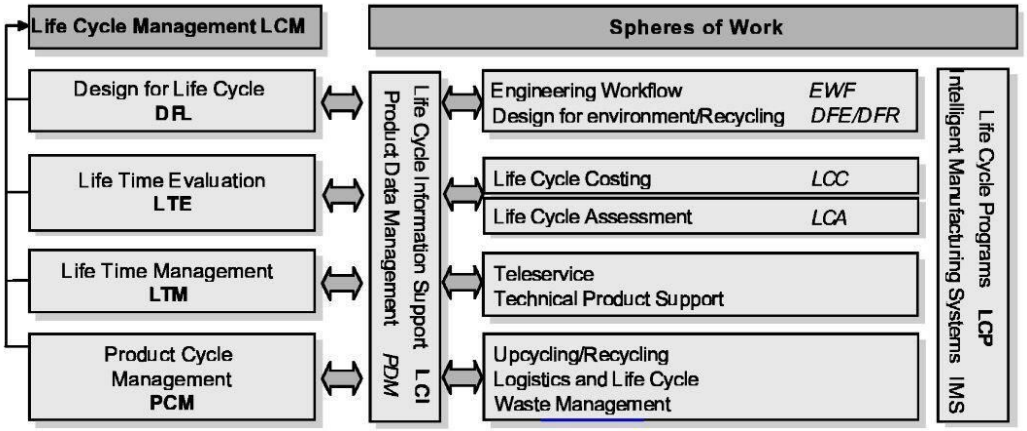

Figure 58. Fields of activities in lifecycle management (Westkamper et al.., 2001).

The design for lifecycle layer focuses on product design and integration of environmental issues and parameters in product development along its lifecycle. Design for lifecycle aims at using less raw material, reducing environmental impact while maintaining or enhancing product's functionality. The authors mention the following tactics, such as the use of renewable materials, material saving manufacturing processes, improved energy efficiency, greener logistics and design for disassembly and recyclability.

The life time evaluation layer focuses on the lifecycle modelling and assessment of the product using LCA and LCC to provide hotspot analysis to the designers.

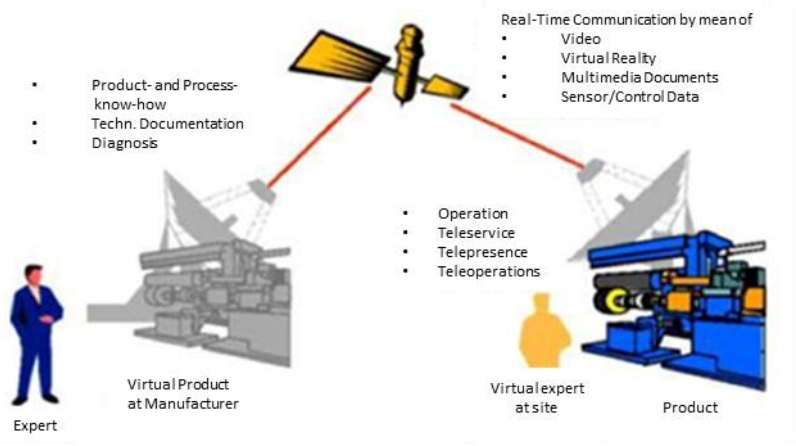

Figure 59. Elements of a holistic tele support (Westkamper et al., 2001).

The life time management layer focuses on the use phase of the product. Life time management aims to apply manufacturer's technical knowledge and know-how to use the product more efficiently by employing information technology like teleservice communication networks (Figure

59). The obtained knowledge can provide new business and product design opportunities, such as after sales service, and develop product service systems where products' lifecycle can be extended.

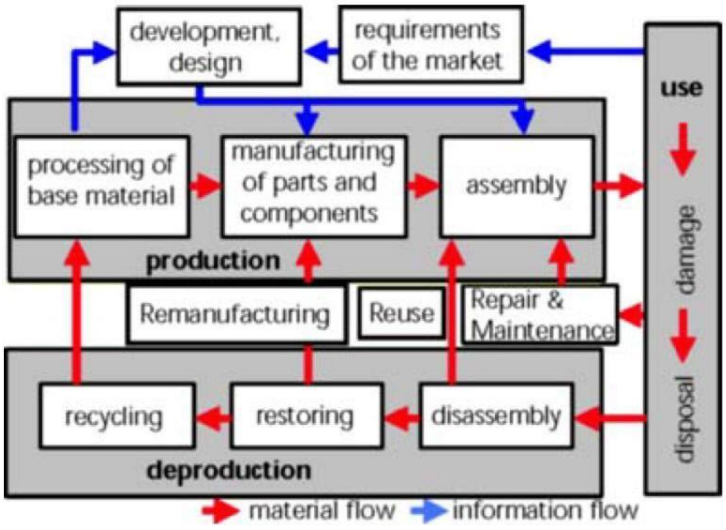

Figure 60. Cycle of materials and information flow (Westkamper et al., 2001).

The product cycle management layer focuses on the end-of-life phase of the product. The authors mention remanufacturing and design for disassembly and recycling strategies to extend the product and raw materials lifecycle.

Westkamper et al. (2001) approach uses lifecycle information to influence product development, use, and end-of-life (Figure 60).

Accordingly, Nakano and Koike (2013) propose the development of LCA data exchange systems to enhance reliability and accuracy of LCAs, and Grambow et al. (2013) suggest a concept of PLM along the supply chain. Zhao et al. (2013) introduced a framework for developing a PLM information system to make available LCI information at the product design stage.

Saur et al. (2003) and Jensen and Remmen (2006)

Saur et al. (2003) is a definition report and Jensen and Remmen (2006) is a report for the development of an LCM guideline, UNEP/SETAC published both reports.

Saur et al. (2003) edited the LCM definition study of the UNEP/SETAC Lifecycle Initiative, a study that covers various LCM aspects that have been previously addressed by different working groups. Saur et al. (2003) proposed LCM as a framework directed at more sustainable patterns of production and consumption that is driven by both business opportunity and risk minimization. The authors see LCM as an umbrella framework where tools that have been used in isolation in the past, now reinforce each other and subsequently enhance sustainability. Saur et al. (2003) presented a toolbox (Figure 61) as a framework that a company could use to find the available options. From the researcher's point of view, Saur et al. (2003) uses a very vague conceptual concept as each environmental related activity is linked with LCM without providing a conceptual framework to connect and guide their use or not. Sonnemann et al. (2015) further developed Saur's et al. (2003) toolbox but there are very limited differences between the two (Figure 62).

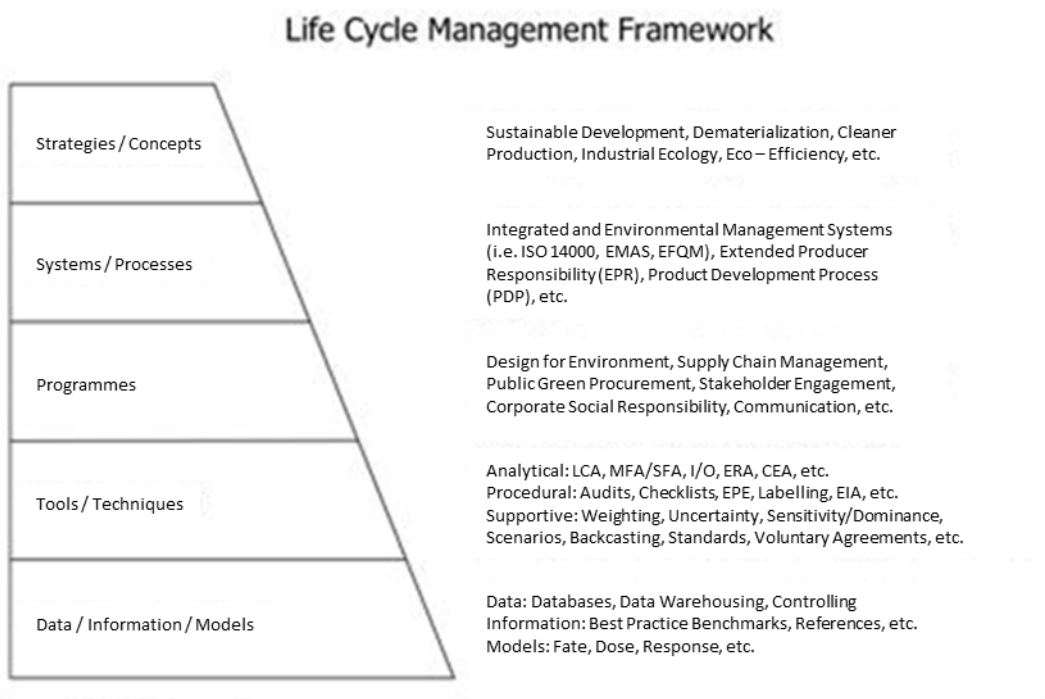

Figure 61. LCM framework (Saur et al., 2003).

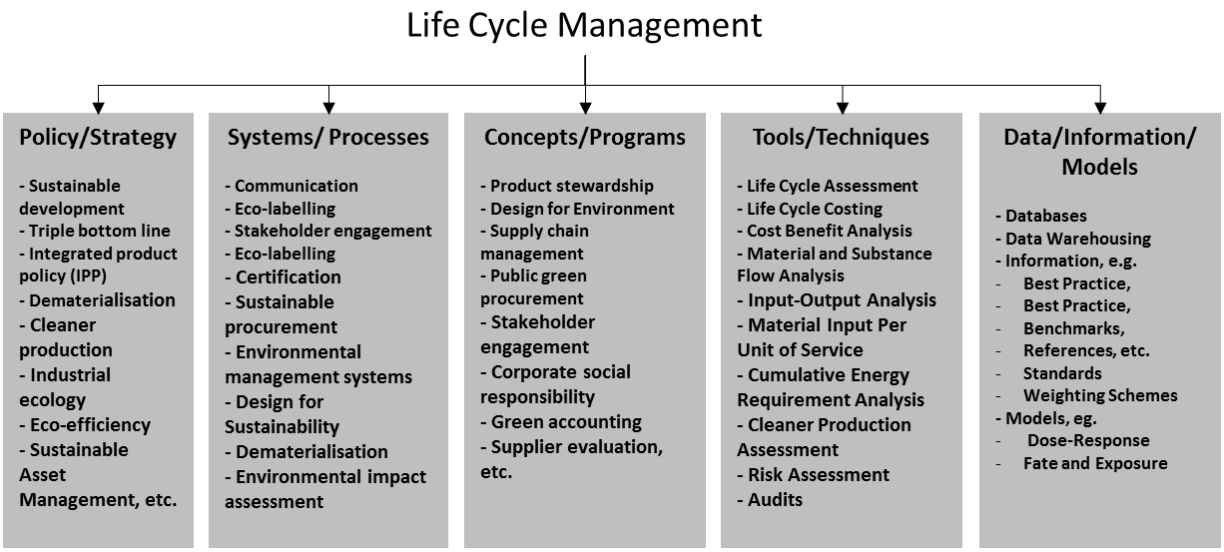

Figure 62. Choice of policies, strategies, systems, programs and different types of tools within the lifecycle management context (Sonnemann et al., 2015).

Saur et al. (2003) suggested four LCM targets, including, lifecycle-based product development, communication of lifecycle information, management across the lifecycle, and stakeholders' responsibility along the lifecycle. The starting point for LCM approach suggested by Saur et al. (2003) is influenced by lifecycle thinking and lifecycle assessment.

The lifecycle based product development target focuses on product innovation and the role of lifecycle thinking in product development process mainly using eco-design approaches.

The communication of lifecycle information target pays attention to product labelling (ISO labels), environmental declarations (EPDs) and certifications (i.e. FSC), and corporate environmental reporting.

The management of the lifecycle target focuses on lifecycle thinking linked with environmental management systems, utilising lifecycle oriented management systems known as product-oriented environmental management systems (POEMS).

The product stakeholder engagement along the lifecycle target addresses stakeholder responsibility and explores the expectations of the various stakeholders, their information requirements and the process of communicating information to them.

Jensen and Remmen (2006) in their report looked at LCM as: '*the application of lifecycle thinking to modern business practice.*' For the first time the authors introduced the concepts of intra- and inter-organisational cooperation providing additional examples. In the report, the authors also consider project management of LCM projects and production process lifecycle management.

The report provides an example of departments' sustainability-related tasks (Figure 63) for intra-organisational cooperation, as lots of the actions that are related to sustainability are not taking place at the sustainability group, or even being influenced/supported by it.

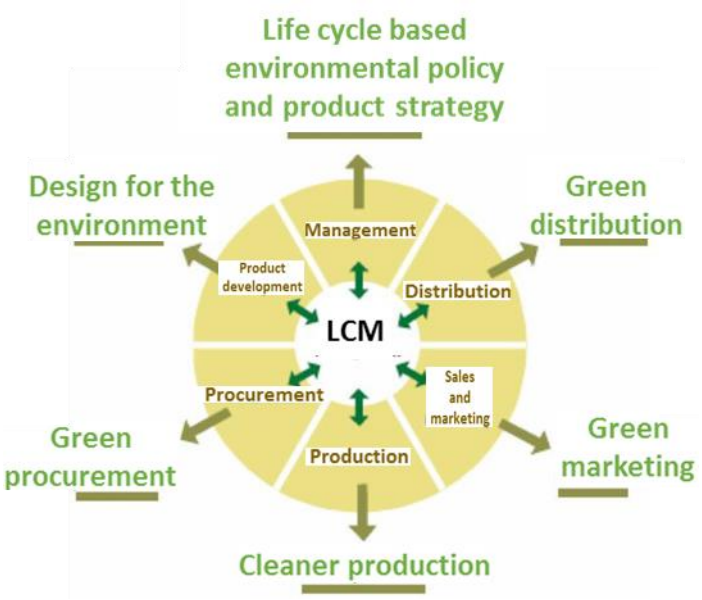

Figure 63. Departments involvements in sustainability tasks example (Jensen and Remmen, 2006).

Also, on inter-organisational cooperation the authors describe interrelations of the actors in the value chain (Figure 64). Therefore, LCM shifts from focusing exclusively on the enterprise's borders to the entire product chain. The network of actors in the product chain is described in Figure 64 and consists of three types of interactions:

- Communication and cooperation among actors along the product's lifecycle.
- Flow of materials from the acquisition of raw materials through the end of product's life.
- Cash and value flow across the product's lifecycle.

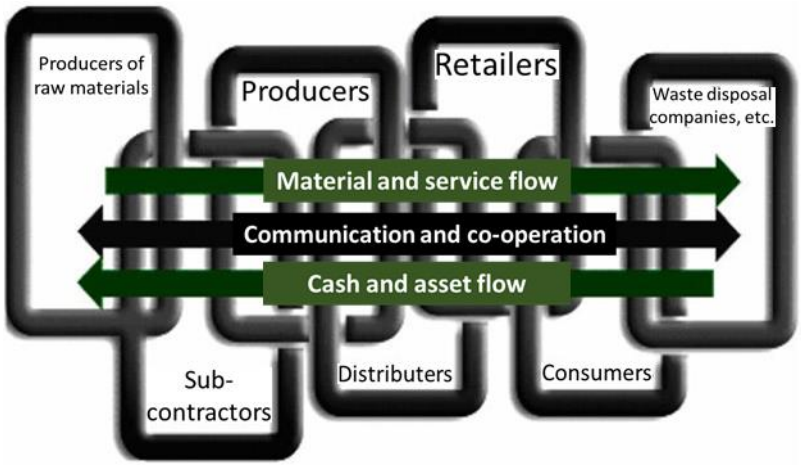

Figure 64. Collaboration across the product chain (Jensen and Remmen, 2006).

Moreover, a project management framework is provided for LCM implementation, as described in Table 51. The PDCA cycle refers only to the implementation and development of LCM as a product with no reference to the other organisationa groups where these actions should be integrated.

Table 51. Deming cycle on LCM implementation (Jensen and Remmen, 2006).

Phase	Approach to LCM implementation
Plan	1. Set policies – set goals and determine the ambition level. 2. Organise – get engagement and participation. 3. Survey – make an overview of where the organisation is and where it wants to be. 4. Set goals – select an area/s where the effort will be directed, determine goals and make action plan.
Do	5. Make environmental improvements – put the plan into action. 6. Report – document the efforts and their results.
Check	7. Evaluate and revise – evaluate the experience and revise policies and organisational structures needed.
Act	8. Survey again, define more goals, etc.

Inspired by Labuschagne and Brent (2005), Jensen and Remmen (2006) addressed production processes lifecycle management, with LCA being focused on the product, while production processes can have significant impacts on the performance of the value chain. The production processes influence the material flows and is more focused on the manufacturing parts across the product chain. Also, Jensen and Remmen (2006) mentioned the importance of location: different locations have a significant impact on the performance, due to variations in location conditions. The latter affects the environmental, economic and societal performance because

different locations can handle a different amount of waste, societal pressure or economic efficiency.

Supportive Concepts

Labuschagne and Brent (2005)

Labuschagne and Brent (2005) base their analysis on project management, looking at companies that are not well equipped to integrate sustainability aspects in organisational processes. According to them, project management is a core organisational process that can be used in addressing sustainability issues. Labuschagne and Brent (2005) introduced a concept that links different types of lifecycle thinking with project management. The authors provide an LCM approach based on corporate project management than product lifecycle.

Labuschagne and Brent (2005) described different lifecycles that a project could consider, including the project, product and manufacturing process/asset lifecycles and their links (Figure 65). At the same time the authors did not provide any further analysis regarding the variations or links between the different lifecycles.

Having different lifecycles types in mind, the authors proposed sustainability criteria to consider in project results. They suggested return of investment (RoI) and net present value (NPV) as indicators for economic sustainability, along with a number of indicators for environmental and social aspects.

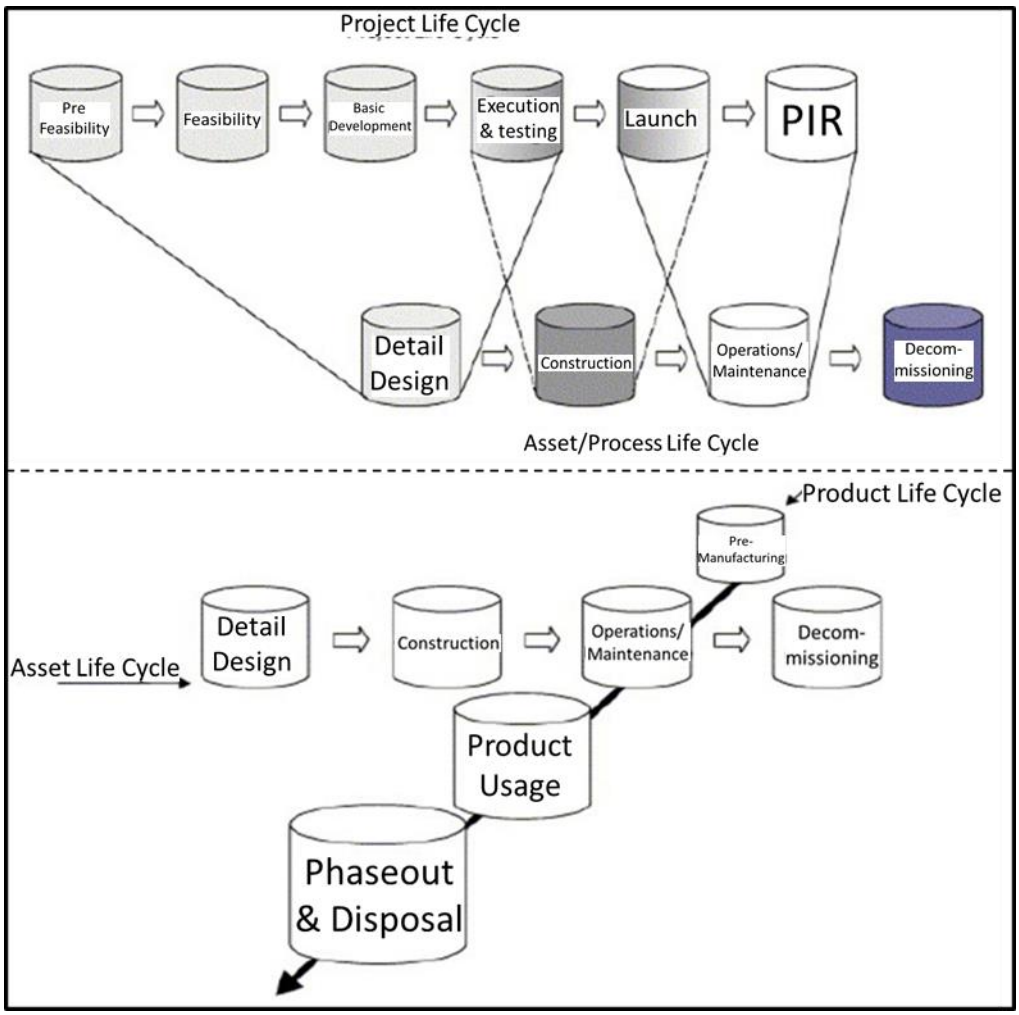

Figure 65. Interactions between Project Lifecycle – Asset Lifecycle and Process Lifecycle – Product Lifecycle. (Labuschagne and Brent, 2005).

Remmen and Thrane (2007)

Remmen and Thrane (2007) described LCM as: '*a business strategy towards sustainability, where the intra- and inter-organisational challenges of industrial organisations' are supported by different management systems and tools such as ISO 9001, corporate social responsibility, lifecycle assessment and eco-design*'. The authors highlighted the importance of POEMS to keep track of both product and production processes.

According to Remmen and Thrane (2007), integrated management systems is a foundation for LCM, this is their approach on how the current management systems could be utilised and enhance the lifecycle performance of products. Table 52 describes the framework provided by

Remmen and Thrane (2007) on the LCM dimensions. The relation between integrated management systems and LCM is also addressed by Jorgensen (2008), highlighting three integration levers across ISO 9001/TQM, ISO 14001/POEMS, and OHSAS 18001/CSR. The levers are management system integration, product focus and integration with stakeholders, and building a learning organisation that allows building up the relevant competencies.

Table 52. The environmental, economic and social dimension of LCM (Remmen and Thrane, 2007).

Dimension		Production site	Product lifecycle
Environmental	**Strategies & systems**	• Cleaner production • EMS	• Product chain and network collaboration • POEMS
	Tools	• Cleaner production guides • BREF notes • Green accounts	• LCA • Eco design • Environmental product declarations • Eco labelling
Social	**Strategies & systems**	• OHS • Employee participation	• Product chain and network collaboration • CSR
	Tools	• H&S tools • Internal social performance indicators	• Social/ethical labelling • Social reporting • Code of conduct
Economic	**Strategies & systems**	• Eco-efficiency	• Product chain and network collaboration • Triple bottom line
	Tools	• Conventional cost accounting • Total cost accounting • Environmental management accounting	• LCC • Environmental management accounting

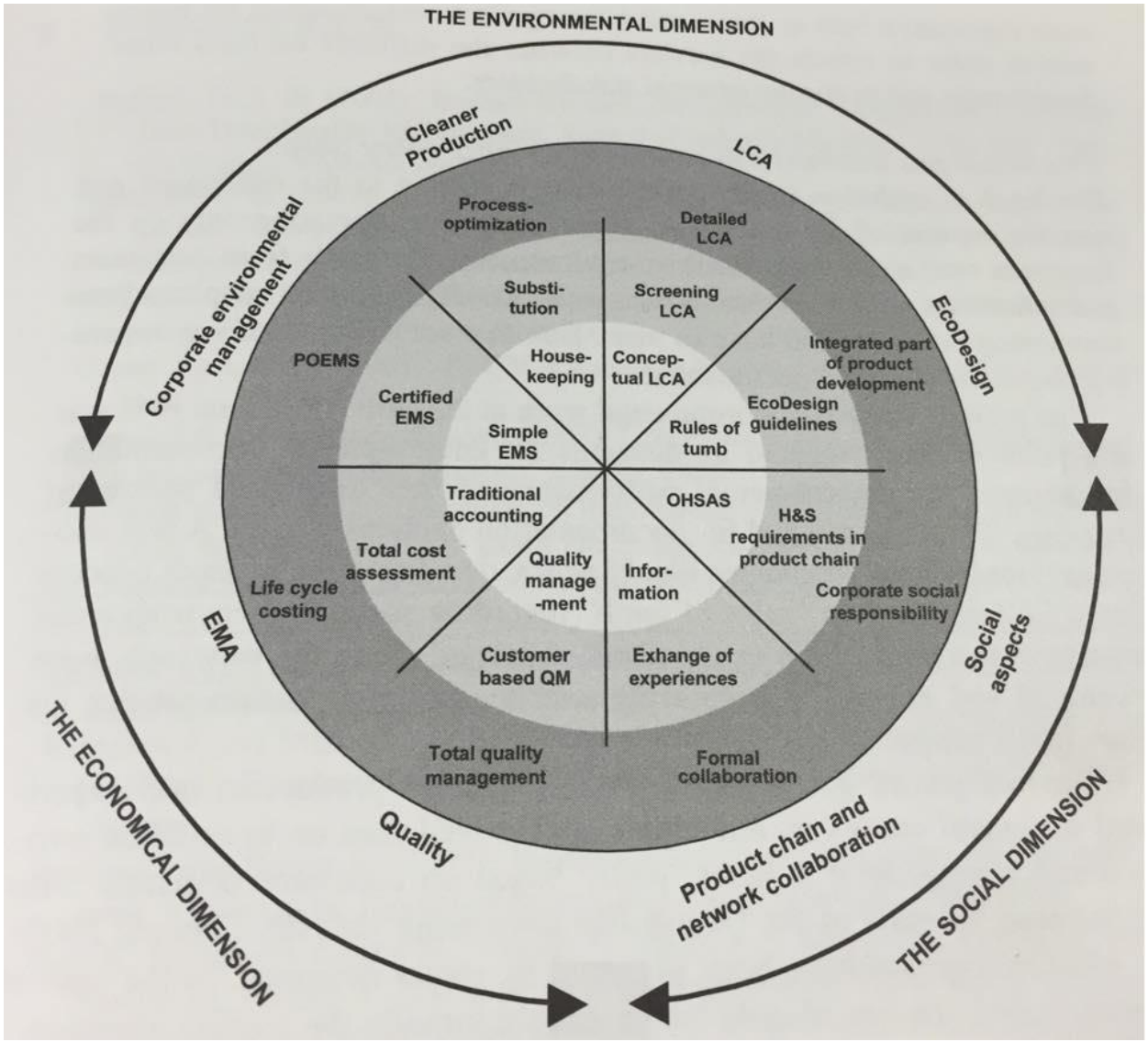

Figure 66. Different ambition levels in LCM (Remmen and Thrane, 2007).

Also, the authors discussed the different LCM ambition levels that could occur in a company which is described in the different rings of the circle in Figure 66. The ambition level at each 'slice' of the circle is independent. Jensen and Remmen (2006) illustrated the issues related to LCM mentioning that is not a static process, but a dynamic one. A company can start with small goals and continue with more ambitious targets over time.

Finkbeiner (2011)

Finkbeiner (2011) provides a supportive concept on the integration of lifecycle thinking and assessment in LCM. He attempted to expand the LCA concept and integrate all three sustainability pillars to provide: '*practical solutions for the implementation of lifecycle approaches into strategic and operational decision-making*'.

He introduced the concept of lifecycle sustainability assessment (LCSA), which is the integration of environmental lifecycle assessment (LCA) with lifecycle costing (LCC) and social lifecycle assessment (SLCA). This assessment provides an overview of the three pillars of lifecycle performance to help the decision maker to condense information. Hunkeler and Rebitzer (2003), and Rebitzer and Seuring (2003) initiated the integration of LCA with LCC. Benoît and Mazijn (2009) and Benoît-Norris et al. (2011) introduced development of an SLCA that could be aligned with LCA.

Swarr et al. (2011) and Swarr et al. (2015)

Swarr et al. (2011) introduced a supportive concept on capabilities building for LCM (Table 53). The model that they created is a structured approach to how to build the organisational capabilities and manage more complex problems as use of LCM is becoming more advanced, and more knowledge is acquired through the application.

Table 53. LCM capability model (Swarr et al. 2011).

Maturity level	Decision process	Boundaries	Metrics
Qualified	Visible team based trade-offs	Projects	Binary yes – no compliance; process outputs
Efficient	Rule based trade-offs to achieve company goals	Enterprise	Process inputs/ outputs; eco-efficiency
Effective	Fact based trade-offs to balance value chain goals	Value chain	Cradle to grave integrated across value chain
Adaptive	Value based trade-offs to co-develop company goals and public expectations	Society	Sustainability, resiliency

Thabrew et al. (2009) and Scandelius and Cohen (2011)

Thabrew et al. (2009) introduced a stakeholder-based framework that could be attached to LCA and aid decision-making in a multi-stakeholder context (Figure 67). Scandelius and Cohen (2011) developed a similar framework with a business standpoint that identifies key stakeholders to help to harness dysfunctional conflict into constructive collaboration with stakeholders along the supply chain (Figure 68). Both approaches focus on the socioeconomic aspects, but one fits for policy projects with a lifecycle view and the other on how an organisation manages the interaction with the stakeholders.

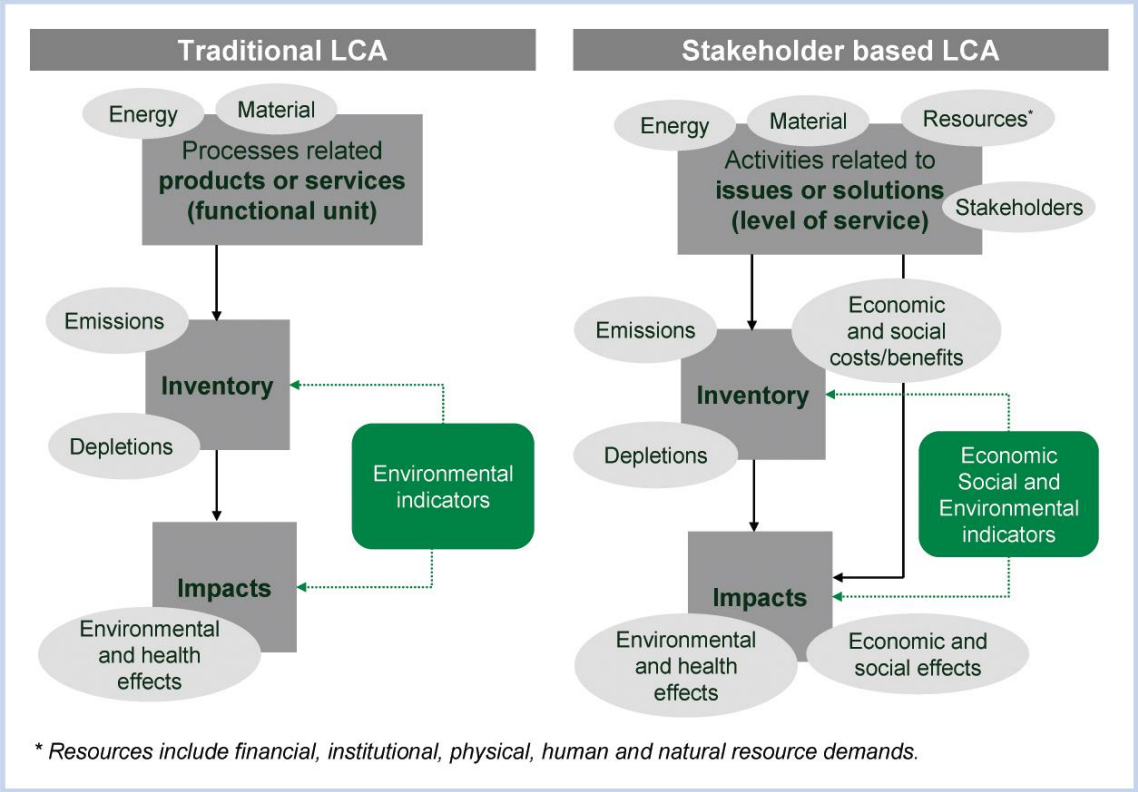

Figure 67. Traditional vs. stakeholder-based LCA clarifying similarities and differences (Thabrew et al., 2009).

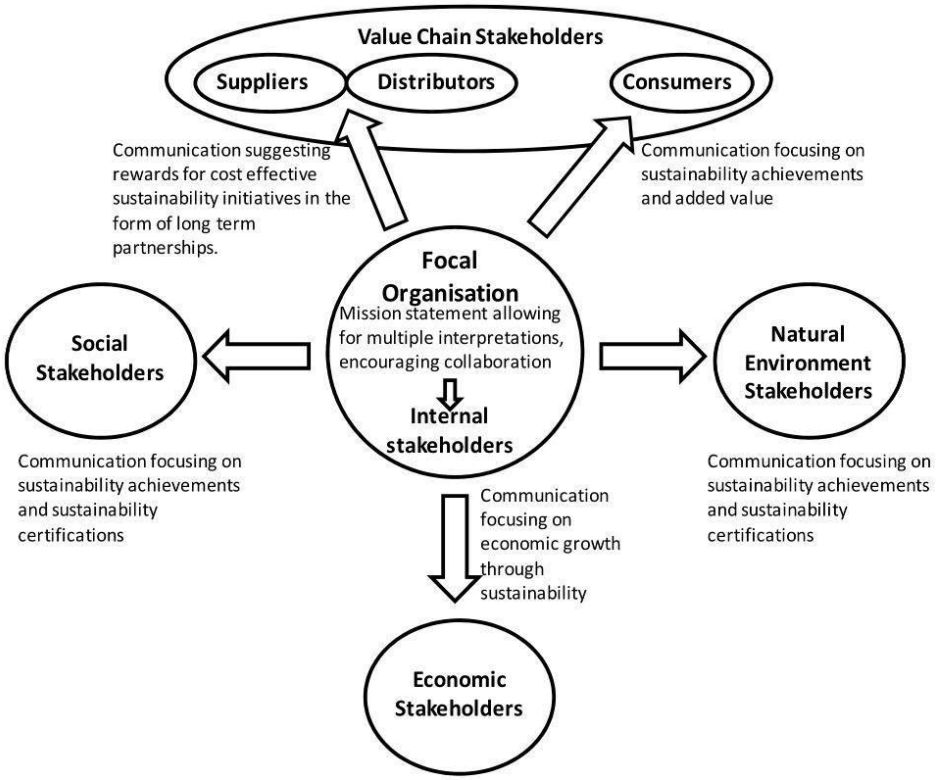

Figure 68. Framework for sustainability stakeholder management in an LCM context (Scandelius and Cohen, 2011).

Appendix 4 – LCM cases description

3M, Fretiere (2001) *and UNEP/SETAC (2009)*

Since 2001, LCM is the second main sustainability initiative after the voluntary initiative pollution prevention pays'. LCM has become a corporate policy and is used to identify EHS regulatory risks and opportunities, and efficient use of resources across 3M's products lifecycle. LCM involves a screening of the advantages, risks and opportunities of various design options throughout the lifecycle. After a preliminary LCM screening, a series of systematic questions are asked for each element in an impact-lifecycle stage matrix. 3M has run the LCM process over thirty times, varying from adhesives, which is a minimal study, to some medical products such as asthma aerosol inhalers. LCM has generally been carried out to improve business growth, save materials or reduce the level of hazardous substances used. LCM supports the company sustainability policies by providing lots of EHS information for projects under development. LCM is a policy that everyone in the organisation has to comply with. However, the organisation is facing one challenge when the sustainability function has to convince the finance oriented functions that LCM brings financial benefits also.

Paint producer, Finkbeiner (2004)

In this LCM case the focus is on a German SME that manufactures paint for industrial applications. LCM was considered as a product oriented extension of the current EMS. The focus of LCA and EMS is quite different, LCA is focused on the improvement of the product through its lifecycle, while EMS on the continual improvement of the performance of the organisation. LCA was used as a hotspot analysis method and it was chosen because of its system perspective and product orientation. The entry gate to LCM was the environmental manager who, after dealing with the low hanging fruits of the EMS implementation was looking for new approaches to improve environmental performance. An opportunity came up to join a university project on LCA, where the university was the LCA consultant. The LCA showed that the improvements in waste and water management do not bring substantial reduction of environmental impact, while the raw materials choice does. The company started considering the environmental impact of purchasing options, which helped to achieve significant improvements.

American National Rubber (ANR), Hunkeler (2004a)

This case is focused on a midsized rubber manufacturer in Kentucky, USA. The company had an economic problem caused by an underperformance of an environmental aspect. The waste disposal costs were high due to the use of a non-recyclable material and one third of it ended up as waste. On top of that, the automotive industry, the main customer of the company, announced that they seek suppliers using higher recycling context in their products and would penalise the companies using only virgin material. That triggered the company to explore the environmental and costing impacts of different material options and strategies, and the emphasis was on LCC. The solution they identified was to recycle two thirds of the polymer by reusing it in the product, and the remaining was sold to carpet manufacturers for carpet backing use.

Ford, Schmidt (2004) and UNEP/SETAC (2009)

In this case the focus is on a large German factory of a global car manufacturer. The case demonstrates the implementation of environmental aspects in the automobile industry. The main LCM aspects addressed in this case, include the use of sustainable materials, lowering car use emissions, lifecycle impacts and costs during the use and end-of-life phase. These are standard practises for automobile manufacturers that involve intra- and inter-organisational cooperation. There are five key areas where LCM activities are listed.

- In research and design, there is research on electronic and fuel cells vehicles, fuel economy, and the product development and design teams have defined environmental aspects integrated in their processes.
- In the supply chain and procurement side there are defined environmental targets to suppliers such as weight, recyclability, recycled and renewable content, restriction of substances. Also, the car manufacturer has initiated design for environment training programs for its suppliers. On top of that, there is very close cooperation between the manufacturer and its supplier by exchanging lots of product information that has helped to outstanding environmental achievements.
- Production and distribution has an established EMS.

- On the sale, marketing and consumer side, the manufacturer provides information on the environmental performance of the product and provides eco-driving courses in collaboration with other stakeholders.
- On the end-of-life part, there are strategies based on the company's integrated product and lifecycle policies. The company uses LCAs and other environmental impact analysis tools, and developed cross car and cross functional teams that share knowledge. It seems that the close collaboration with value chain actors makes a difference for this case. The integration of environmental aspects was carried out by multiple departments.

The company uses a product sustainability index (PSI) that is certified against ISO 14040 on LCA. This tool covers the product development function. The company has developed tools to support the decision-making of other functions such as manufacturing, HR, etc. The company mentions that PSI is their LCM system focusing on economic, environmental and social aspects. An LCM system was introduced as a tool to be used by the relevant function that needs the information from a distant sustainability team. The tool is part of the product development process and certain targets and milestones are set. The company works very closely with their suppliers on environmental and social issues. This is a task of the purchasing team that ensures that the standards are met by the suppliers.

Another important aspect of the successful implementation is that all lifecycle stakeholders (material and part producers, logistics companies, customers, NGOs, academia and end-of-life operators) were involved, they played a certain roles and targeted the improvement of the lifecycle performance of the product.

MAN Technologie AG, Rebitzer (2004)

This case is on a German SME that is active in aerospace parts production. The trigger to adopt LCM was the willingness of the company to be proactive with legislation and customers' demands. In aerospace, the light-weight parts that meet the mechanical requirements reduce cost and environmental impact. The company joined a multidisciplinary project offered by a university with focus on material selection during product development. The university in collaboration with the manufacturer and its suppliers conducted a study focusing on material

choices for a specific aeroplane part. The study explored the complete environmental and costing lifecycle assessment of different material options. The study showed that the use phase is the dominant part of emissions and costs, and it allowed to identify the material which had the best combination of low environmental impacts and costs. This information was useful for the R&D department, as now they know they have focused their attention on this material. This project was based on collaboration between manufacturing and product development functions, while the environmental department was involved to a lesser extent.

UNARCO, Hunkeler (2004b)

A USA based SME that is active in metal furniture market conducted a joint environmental and economic assessment to identify an alternative to a current process that has environmental, safety and disposal cost issues. The interest for this LCM study was to explore manufacturing process alternatives for replacing a process that has paint sludge as by product that ends up as waste. The company approached a university team to help them conduct a risk assessment, a LCA and a LCC of the alternative processes considering manufacturing, logistics and disposal. As a result, the current situation and three alternatives were assessed. The first alternative option had much lower risk, but the cost was high and the technology was not commercialised yet. The second option had a lower cost and risk than current situation. And the third option was identical to the current situation. The management of the company considered the results of the environmental and costing assessment in their decision-making and selected the second option.

AQUA+TECH Specialties S.A., Hunkeler (2004c)

This is a case of a start up in the waste water treatment market in Switzerland that used LCA and LCC before the actual implementation stage in order to design a process, market it and attract investors. The company conducted comparative LCA and LCC analysis to identify the hotspots of current processes. The study identified the following problem: the water content of the sludge significantly increased the cost of transportation. It was calculated for the case municipality that each percentage of water content reduction in sludge saves 2$/capita/annum. The company managed to come up with a process that reduced 2% the sludge water content, decreased

chemical consumption by 30% and minimised the electricity consumption due to mechanical filtration.

USEPA's eco-purchasing initiative, Saur (2004)

This case comes from the US Environmental Protection Agency and is focused on the five principles of the USEPA's environmentally preferable purchasing initiative. This initiative is an LCM case of providing support in decision-making to identify the purchasing option with less environmental and health impacts. The five guiding principles include:

1. Environment + Price + Product efficacy = Environmentally preferable purchasing. Environmental factors should be part of purchasing process.
2. Pollution prevention - Eliminate or reduce impact on health and environment.
3. Lifecycle thinking - Consider the product's performance across its lifecycle.
4. Comparison of environmental impacts - Compare the performance of competing products.
5. Environmental performance information - Collect meaningful and accurate information of products.

The business perspective of this initiative is twofold, to reduce environmental impacts and reduce the cost of ownership of products, as many of them have the largest costs during the use phase. This cost could be associated with handling, monitoring, storage, treatment and disposal. LCM tries to enhance the decision-making process by providing better information to decision makers.

Unknown automotive company, Rebitzer and Buxmann (2005)

Rebitzer and Buxmann (2005) provided an LCM case study focusing on the car floor options that an automobile industry had and tried to identify the best option from the environmental point of view. This paper covers only the environmental side through a comparative LCA.

Collaborative project on packaging, Poikkimaki (2006)

Poikkimaki (2006) describes a collaborative project on packaging and packaging materials. In this case there was a collaboration between two research centres, the packaging association, the three largest breweries of the country, the two largest retail chains, and numerous companies in the beverages network. The task of the case was to provide LCA data on beverage packaging to be used by the collaboration network and stakeholders' communication.

This project provided knowledge to participants, they came across environmental efficiency, the complexity of assessment, improvement actions, and connections between economic and environmental considerations. Also, they explored the environmental related interaction and cooperation across companies, and this cross actor discussion produced many practical environmental improvements.

Unknown, Yamaguchi et al. (2007)

Yamaguchi et al. (2007) used LCA and LCC in a case study to identify the optimal solution between two machines. The majority of the results were in favour of one product, so the integration of results would not add something more to the decision-making. In their theoretical framework they used cost benefit analysis (CBA) to support decision-making.

Hartmann A/S, Holgaard et al. (2007)

Hartmann A/S is a multinational Danish company that is active in packaging production, it is well known for its good sustainability performance. The emphasis of the company is both on environmental and social performance mainly through ISO 14001 and OHSAS 18001 implementation and continuous improvement. They have their own environmental and sustainability model and LCM is one of the main elements. The LCM process has three steps: data collection, LCA development and LCM implementation. Continuous implementation of the overview from the lifecycle studies is considered by all relevant business decisions. The major business decisions are on strategic planning, product development, purchase, production, distribution and sales. Their strategy is to develop simple tools that can be used by non-experts and gradually implement into everyday decision-making. Another important aspect of the intra-

organisational cooperation is the share of knowledge through network activities, training and workshops. It is interesting that workshops have three rules: tell what is in your mind, find opportunities – no limits, have tried but does not work. The company has established the role of LCM ambassador that has to establish and maintain the functional cooperation and coordinate the exchange of improvement proposals.

Grundfos A/S, Holgaard et al. (2007)

Grundfos A/S is a multinational Danish company that is active in pump and electric motors. In this case LCM is not a frame of reference for the company, but several LCM activities have been implemented. The company has a decentralised system where the ownership of activities is close to the departments affected. In this way the tools and goals are according to the local routines. Another important aspect is that the person working on product environmental initiatives is part of the central function that environmental activities are included, and can have an understanding of the functional routines of each group. The intra-organisational cooperation exists informally through the cross functional projects that are run by the central function. Furthermore, some production units have established a process where local working groups exchanging experience and ideas with other groups on environmental improvements. The site environmental create a culture for environmental communication in daily practice. On inter-organisational cooperation, the company work with distributors on reducing the environmental impact of logistics and initiated a labelling scheme for the market that the company is active. Last but not least, the lifecycle thinking view of the company is proactive, as they give emphasis in not solving a problem in a part of the product chain, but at the same time causes rebound effects on another part of the product chain.

BASF SEEbalance, Remmen et al. (2007)

BASF developed an eco- and socio-efficiency quantitative analysis tool to assess products and processes. The assessment is conducted from the customer's angle and is giving equal importance to economic, social and environmental aspects. The tool also provides the option to assess future scenarios and different options. The tool can be used for strategic decisions

(related to investments, markets and products comparison), comparison of products, processes, and markets, communication of performance.

Vestas wind turbines, Remmen et al. (2007)

Vestas used LCA information to identify the hotspots of wind turbines production and installation. This knowledge helped in reducing the material consumption in wind turbines. Also, the company used LCA to prove to stakeholders that wind turbines use less energy to manufacture compare to the energy they produce during their lifecycle.

Philips, Remmen et al. (2007)

Philips established a product development scheme called Green flagship status. This is an eco-design tool based on six green focal areas. A product is compered to its successors and closest competitors using a tool that assess the lifecycle performance of the product. A product is getting the green flagship status when it has significant better performance than the other products. This process helped Philips develop more than 200 green flagship products.

Johnson & Johnson, Remmen et al. (2007) and Fava and Iannuzzi (2013)

Johnson and Johnson uses LCT to reduce the environmental impact of products and deliver better value to customers. The company developed a sustainable design tool based on lifecycle screening. The tool is focused on seven key areas of concern, provides assessment and identifies potential areas for improvement. The tool helped the company's products to be recognised as the best in their product categories. This helped make a business case that is focused on more marketable products, but also environmental and costing efficiencies in certain products such as cutting the transportation fuel by 95%, increase the use of environmentally friendly materials by 40%, achieving 78% reduction of water use, reduce packaging material use by 50% and use of only sustainable materials, reducing GHGs by 70% in the distribution system. Johnson & Johnson keeps a track of the avoided lifecycle costs that result from environmental efficiencies. The costs include activities such as purchasing, transporting, storing, treating, and disposing of materials. This has helped the company develop strong business case for its environmental strategy. It was

also identified that the product teams that use the tool have improved considerably their skill and knowledge on LCT and help them create more marketable products, drive business success, translate technical data and communicate the environmental benefits to stakeholders.

Alcan packaging, UNEP/SETAC (2009)

Alcan is a world leading packaging manufacturer with a target to be aHead of competition in sustainability. The key people in the company (management, R&D, communications, sales and marketing) are on board and support the sustainability initiatives. It is not only the EHS department that drives sustainability. In Alcan's case, R&D and marketing are the functions that drive it as they see the marketing opportunity. They see sustainability not as a project with an end, but as an ongoing business process aiming to improve the products sustainability performance. The EHS department is small and flexible and coordinates the actions happening at other departments and drives the LCM actions. The company has LCT and LCA as a base on product analysis, and have created their own sustainability evaluation tool. The tool does not measure monetary values; it has a quality management approach. Alcan works very closely with their customers on the sustainability of their packaging solutions, as customers are very interested in the lifecycle sustainability of the packaging they use. Alcan also works with their global network of suppliers on environmental and labour concerns.

Dow chemical, UNEP/SETAC (2009)

At Dow chemical embracing LCM is very important in creating the successful products of tomorrow. The company's customers are becoming more and more knowledgeable on sustainability and having their own customers that are very sensitive too. This market interest trigger various departments in the company to be aware of their sustainability state and how this can be improved. The main tool used by the company is LCA. The company addresses many sustainability aspects, but the one that they see the largest potential is on sustainability chemistry focusing on chemical issues from cradle to grave. The company applies LCM through the various initiatives related to the ten-year sustainability plan of the company.

Eskom, UNEP/SETAC (2009)

Eskom is the largest power generation company in Africa. LCM in this case is used to prepare the company for complying with the strict legislation that is going to be enforced. Eskom's main issues are air quality, waste and environmental impact management. The sustainability team of the company is focused on factoring the LCA information to be considered in investments in new or existing assets. Especially for new investments the timeframe of the decisions to be made are for 2050. Another aspect of the sustainability work is the assessment of the business implications on climate change regulation locally and globally. The company is also working on location specific issues, for example there are operations in water stressed areas and Eskom developed a dry cooling technology that uses less fresh water.

United Technologies, UNEP/SETAC (2009)

United technologies is a manufacturing and service provider of elevators, aerospace and aircraft systems, air conditioning and power generation equipment. As far as products is concerned, the sustainability focus of the company is the elimination of use of certain materials of concern. This is a corporate goal comes from the chairman with the mind set of aligning with the strict regulations that EU is going to enforce. On the manufacturing process there are certain targets for GHG emissions reduction per year. On the building side, there is a target that each new building should be certified with LEED gold as a target.

Veolia environment, UNEP/SETAC (2009)

Veolia is a services provider that focuses on water treatment, waste management, energy and transport. In all these sectors the customers expect the company to provide services with good sustainability performance. The main task of their environmental team is to evaluate the environmental impacts and risks to support the decision-making process of the company. Veolia uses LCA as a basis for their own sustainability tool, but also risk assessment, cost benefit analysis, water and carbon footprint, and biodiversity indicators are utilised. The environmental team share their knowledge and drives initiatives to increase the creativity of the company on

sustainability issues. This has fostered many people in the company from various functions to follow the LCM approach.

Unilever, Unger et al. (2011) and Unger and King (2013)

Unilever is a company that aligned their business plan with sustainability. In 2010, the company publicly announced the sustainable living plan. The main target is to half (2008 is base year) the environmental impact (GHG, water and waste) of the value chains by 2020. The company conducted LCAs for about 70% of the company's sales globally. The study showed that only 5% of the impact is a result of Unilever's own operations and the majority on the impact is across the value chain. The focus of the plan is not only on environmental aspects, it considers economic and social issues across the vale chains. The results of the value chain analysis provide insights for business decisions and guides R&D and product development processes. For this challenging plan the company has conducted projects on the use phase of the product analysing customers' habits and try to identify improvements. On the supplier side, they have already analysed certain processes in the supply chain that have large impacts and work with their suppliers to reduce impacts. The obtained information from the environmental impact analyses are used in the project management process to challenge and reduce future products. Very important for this project was that senior management's commitment and the integration of the plan with the business objectives instead of being a separate activity. This allowed many functions such as marketing, R&D, supply chain, packaging, IT and finance to get involve in the project.

Walt Disney, Brown et al. (2011)

Walt Disney developed a LCM platform that is based on LCC and LCA to support the decision-making process at Walt Disney Imagineering with costing and environmental information for the design process. The provision of lifecycle information to park designers and planners in a suitable and comprehensive way is very important for the development and use of LCM by the company. The integration of the tools in the design process will allow the company to improve the sustainability of their parks.

Walmart Chile, Emhart et al. (2013)

Walmart in Chile implemented a benchmarking study on its supplier base using quantitative indicators for the identified environmental and social hotspots. The survey informed each supplier on their environmental, social and economic management performance and informed them on the average score for each dimension. On top of that, the company delivered several workshops and provided guidelines to supplier on how to improve their performance.

ABB, Petersson et al. (2013) *and Carlson et al. (2013)*

ABB has two LCM cases. Petersson et al. (2013) used comparative LCA studies to aid the decision-making on the material selection process. Carlson et al. (2013) present a conceptual framework on the development of sustainability-related information system to aid business decision-making.

Siemens, Uebelhoer et al. (2013)

Uebelhoer et al. (2013) informed about an PLM system initiated by Siemens to manage greenhouse gases (GHGs) along the supply chain. The aim was to expand Siemens sustainability strategy on the supply chain by optimising environmental and energy efficiency potential, and bring transparency and awareness across the supply chain. The company collaboratively worked with suppliers and at the end provided a report with results and recommendations. In this way the company wants to build on its experience and develop a standardised supply chain management system.

VW, Warsen et al. (2013) and Broch et al. (2015)

VW initiated the Think Blue concept to develop technologies that reduce co2 emissions of vehicles. The Analysis department decided the aspects of environmental compatibility and address them at an early stage throughout the organisation and at all stages of the product life-cycle. The Technical Development department set the target to constantly improve the environmental compatibility of its facilities and products, and all processes across the lifecycle of their products will be environmentally friendly. VW uses LCA to assess the current situation and

develop specific goals for the engineers and planners to develop concrete projects. The company also provides information to each stakeholders on their environmental performance and how they achieve improvements.

Barilla, Ruini et al. (2013)

Barilla conducted LCA on their products and process and through this process identified lots of opportunities for improvement that led to projects on various stages of the products lifecycle. They conducted projects on more sustainable cropping systems and production of most important raw materials, lots of energy efficiency and cogeneration projects on their own processes, assessing the current packaging lifecycle, improving the performance of the logistics network, and conducting a project on changing the performance of household cooking.

Danone, Bligny et al. (2013)

Danone has decided to develop water sustainability strategy. The company has recognised that water resources consumption is a key sustainability issue. The company is not new in water efficiency, they reduced their processes water consumption by 43% in 2000 and they continue to make improvements each year. Danone realised that the major hotspots are in the value chain. According to Danone, companies tend to focus on their own production processes only instead of the processes across the value chain and this leads in working on less important issues. Danone created a water footprint tool that will help them understand the upstream and downstream water use in the value chain considering the local specificities. The company used an LCA approach in identifying and analyse the important water issue that they should focus and improve them through collaboration with value chain partners.

Nestle, Schenker and Espinoosa-Orias (2013) and Adams et al. (2015)

Nestle in the past developed an LCA software to help packaging designer integrate environmental aspects in their decision-making. After the success of this tool, the company decided to advance this LCM approach by developing a tool that will help product designer with eco-design. The tools allow the designers to experiment on the environmental performance of alternative designs and

using the information provided the decision makers are able to have a clear idea on the environmental performance of the product from an early stages of the design process. In this way, the designers have the freedom to conduct their own assessments instead of having to find the information in reports or be informed by someone. The tool considers variable aspects such as responsible sourcing, ingredients, processing, distribution, use phase, and food waste along the lifecycle.

Appendix 5 – LCM case analysis

Below is an LCM literature case which contains the four LCM elements analysis marking as an evidence of literature analysis.

Bringing the **life-cycle perspective** into environmental management systems

(Matthias Finkbeiner, 2004)

Summary

This LCM case study illustrates how life-cycle assessment (LCA) can be used to support an existing EMS. The case study revealed that the environmental improvement strategies of an SME in the field of paint production—based on an EMS/production view— were inefficient. The use of LCA confirmed that the improvements in the field of waste or water management do not lead to a significant reduction of the overall environmental burden, because the raw materials (binders, pigments, etc.) they purchase account for by far the largest share of it. As a consequence, the purchase and choice of raw materials was defined as a new focus to improve the environmental performance.

Definition

Why? The company of this case study is a 300 employee Germany-based SME founded in 1926. The core business is the production of paint for industrial applications. This includes solvent-borne waterborne and powder-based coatings. The annual product output of approximately 7000 types of paint totals about 12000 metric tonnes. More than 800 different raw materials enter about 500 production steps. The company recognised the potential to differentiate itself by offering environmentally preferable products and started powder coat production as early as the 1970s. The company identified worker safety and environment as key management guidelines. The company has some major clients, especially for powdered coatings, that place high importance on the environmental profile of their suppliers. The firm began implementing an EMS in 1995 and obtained certification according to the European eco-management and audit scheme (EMAS) in 1996.

What? For the company, LCM consisted of a product-oriented extension or optimisation of the existing EMS. Basically, LCA was used to complement the EMS. From a theoretical viewpoint, LCA an EMS provide answers to quite different questions. While LCAs study products over the **whole life cycle**, EMSs aim at the continual improvement of **organisations**. For an academic discussion of LCA and EMS, it is important to relate to these different aims. However, from a practical and less structured viewpoint of the main users of both tools, that is, companies, they might be seen to serve the same purpose in providing answers to the question of how the environmental performance of a **company** and its products can be improved. LCA was used for weak-point

analysis in order to define targets and programs. LCA was chosen as a tool because of its systems perspective and product orientation.

How? The **company joined a multi-client project**, which was led by a university as the LCA consultant. This multi-client project was partly funded by the regional government to promote the use of LCA in SMEs. As case studies, the company selected typical paint products, for which exemplary LCAs were performed together with the university. Information and data were obtained from internal process and EMS data, contact with their up- and downstream supply chains, and from the university that had carried out LCAs previously. Based on the LCA results, optimisation strategies were defined and implemented into the EMS.

Who? The environmental manager of the firm carried out the operational work. He had support from the technical managers of the product lines powder coat, waterborne coatings, and solvent-borne coatings. The director of the company attended the kick-off and final presentation meetings.

Entry Gate and Drivers

Entry gate

The entry gate of LCM into the company was the environmental manager. After the successful the 'low-hanging fruits' based on corporate ecobalances, he was looking for new approaches and tools to continually improve the environmental performance. A **partly government-sponsored** LCA project provided the opportunity to experiment with and apply a life-cycle—based tool at an affordable budget.

Drivers

Product

The company generates the major share of revenue with 'environmentally sound' paint products, that is, powder coats and waterborne coatings. It is the product that largely determines the corporate image.

Organisation

There is an efficient EMS organisation in place. However, product issues play only a marginal role, and responsibilities for the environmental performance of the products are not clearly defined.

External pressure

Products, processes, and the plant are heavily regulated. As part of the … and a major industrial plant in a small town, management faced the need to cooperate with (critical) stakeholders.

Supply chain

There were no supply-chain pressures or initiatives from the raw material suppliers. However, on the customer side, there were in some cases strong preferences to deliver environmentally sound products.

Implementation

Companies, in particular SMEs, cannot devote a large effort to an academic analysis of what type of tool could be used for a particular problem. In addition, they will not use all of the EM tools. Most of them will try to establish one common approach to achieve sound EM. Both LCA and EMSs are valuable tools for improving the environmental performance of **organisations**. Due to the **company-oriented**, procedural approach of EMS and the product-oriented, analytical concept of LCA, they are methodologically not compatible, even if at first sight similar system elements like the input—output analysis of material and energy flows are compared. The integration of the analytical EMS element corporate ecobalance (CEB) into LCA might be theoretically possible, but practical relevance is questionable due to different system boundaries and different reference units, parameters, and data. A promising solution might be a **company or situation-dependent** combination of LCA and EMS in an ideal sense in an orthogonal manner. A sensible and comprehensive combination of complementary elements might increase the efficiency of EM efforts towards ecological and economical sustainability.

The company began their LCA activities on a project basis. As a starting point, the main interface between LCA and EMS, which is obviously the evaluation of the potential environmental impacts associated with the respective economic activities, was analysed. From a practical and economical point of view, it is desirable that CEB data could be used for LCAs, that is, LCAs could be compiled by aggregating several 'gate to gate' energy and material balances of **companies** and vice versa. At first glance, there is no reason why this should not be feasible. However, in many LCAs and CEBs, the parameters and data used are somewhat different. Specifically, the parameters that are relevant for an LCA are flows that cross the border between technosphere and ecosphere. They are referred to as 'elementary flows' and 'product flows'. As a consequence of the life-cycle concept, the elementary flows consist of resources on the input side and emissions on the output side only. All intermediate products are followed back to their origin, that is, the intermediate flows are completely within the technosphere and therefore are inputs and outputs of processes but not of the final life-cycle inventory (LCI). In EMS, the flows that enter and leave an organisation are relevant. Therefore, intermediates are found in the input—output scheme of CEBs. CEBs require data on the full magnitude of the processes.

Another difference in the parameters studied between LCAs and CEBs is the stock. In a classical LCA, all processes are assumed to operate at a steady-state level and at regular operation conditions. Only the allocated net inputs and outputs are used to calculate the LCI. In a CEB, the stocks of materials and the consumption due to nonregular operations are considered. Because the storage of chemicals has considerable environmental risk potential, CEBs deliver more

information on that aspect than do LCAs. In the case study of the company, it was revealed that, apart from the parameters themselves, the data to quantify the parameters have a different type, too. This can be demonstrated by Figure 4-1 and Figure 4-2, which show CEB and LCA results for the primary energy demand of the production (compounding) of 1 kg of paint.

As mentioned earlier, CEB and LCA theoretically answer different questions. However, the studied paint producer used the respective information for the same purpose of optimising the production process.

The LCA results for 2 types of paint (LCA paint A, LCA paint B) were compiled according to ISO 14040 methodology, including intermediate and raw material production (ISO 1997). For the CEB results, 1 kg paint was employed as an EMS indicator. This measures the specific energy demand per kg paint by dividing the energy demand of the CEB by the amount of paint produced. All the raw data are from the same company.

Figure 4-1 examines the results of the compounding step in detail. The primary energy demand for compounding according to the CEB is higher than both of the LCA results. This can be explained by the different data types used to quantify the respective parameters. For the LCAs, paint-specific energy data of steady-state operation are used. The CEB data represent the overall energy demand. The main difference is the energy consumption for business sectors like administration or research and development (R&D) or room heating, both of which are included in the CEB but not accounted for in an LCA. To neglect these data within an LCA is a convention, in principle, not inherent to the tool. However, to include this information in an LCA would lead to significant allocation problems because these activities relate typically to the whole product spectrum rather than to an individual product.

Figure 4-2 shows the LCA results for the complete life cycle divided into the life-cycle stages (raw materials, transport, and compounding) as well as the CEB result (compounding step only). It is expected that by adding the energy demand of further life-cycle stages, the result of the LCA is higher than the CEB. It is revealed that by far the largest share of the environmental burden is produced outside the factory gates of the paint producer (i.e., the CEB results which only account for the compounding step describe 5% to 15% of the potential environmental burden). Therefore, a large optimisation potential for the paint producer is the choice for the raw materials. This information is obtained only by LCA.

An advantage of the LCA results is that different types of paint can be compared. In the examples of Figure 4-1, the energy demands for paint A and paint B differ by a factor of 3. The CEB yields only an average energy demand for an average kg of paint.

The main conclusion of the company was that its strategies, targets, and programs to improve the environmental performance of its **organisation** had to be redefined. According to its EMS and CEB, the **company** placed a large emphasis on production issues, for example, reduction of waste and water or energy consumption. The LCM approach to complement the **company's** EMS with LCA revealed that these areas are responsible for only a minor share of the total

environmental burden. The major fraction consisted of the raw materials (e.g., binders, pigments) it purchased. As a result, the purchase and choice of raw materials was defined as a new focus to improve the environmental performance.

Tools

The methodologies and tools consisted of a relatively standard EMS and LCA approach. The added value was obtained by combining these 2 tools. From the EMS perspective, LCA as a complementary tool could assist in a number of ways. Specifically, LCA can

• complement the organisation-oriented, procedural EMS tool by investigating main or environmentally relevant products,

• assist in prioritising the objectives of an EMS,

• assist in achieving the objectives of an EMS by a detailed weak-point analysis of the production process,

• help to add objective and scientific elements to environmental performance evaluation (EPE),

• reveal what share of the overall environmental burden of an **organisation** is produced 'inside the gates' and 'outside the gates',

• consider the use phase of products, which often is the life-cycle stage with the highest relevance,

• assist in DfE,

• assist supplier audits and choice of materials, and

• assist in investment decisions.

For the LCA part, one of the commercial LCA software tools was used.

Appendix 6 – Factors analysis – text extraction

Below is a part of the case described in the previous appendix. The extracted text is shown by highlighting.

Bringing the life-cycle perspective into environmental management systems

(Matthias Finkbeiner, 2004)

Summary

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What? For the company, LCM consisted of a product-oriented extension or optimisation of the existing EMS. Basically, LCA was used to complement the EMS. From a theoretical viewpoint, LCA an EMS provide answers to quite different questions. While LCAs study products over the whole life cycle, EMSs aim at the continual improvement of organisations. For an academic discussion of LCA and EMS, it is important to relate to these different aims. However, from a practical and less structured viewpoint of the main users of both tools, that is, companies, they might be seen to serve the same purpose in providing answers to the question of how the environmental performance of a company and its products can be improved. LCA was used for weak-point

analysis in order to define targets and programs. LCA was chosen as a tool because of its systems perspective and product orientation.

How? The company joined a multi-client project, which was led by a university as the LCA consultant. This multi-client project was partly funded by the regional government to promote the use of LCA in SMEs. As case studies, the company selected typical paint products, for which exemplary LCAs were performed together with the university. Information and data were obtained from internal process and EMS data, contact with their up- and downstream supply chains, and from the university that had carried out LCAs previously. Based on the LCA results, optimisation strategies were defined and implemented into the EMS.

Who? The environmental manager of the firm carried out the operational work. He had support from the technical managers of the product lines powder coat, waterborne coatings, and solvent-borne coatings. The director of the company attended the kick-off and final presentation meetings.

Entry Gate and Drivers

Entry gate

The entry gate of LCM into the company was the environmental manager. After the successful the 'low-hanging fruits' based on corporate ecobalances, he was looking for new approaches and tools to continually improve the environmental performance. A partly government-sponsored LCA project provided the opportunity to experiment with and apply a life-cycle—based tool at an affordable budget.

Drivers

Product

The company generates the major share of revenue with 'environmentally sound' paint products, that is, powder coats and waterborne coatings. It is the product that largely determines the corporate image.

Organisation

There is an efficient EMS organisation in place. However, product issues play only a marginal role, and responsibilities for the environmental performance of the products are not clearly defined.

External pressure

Products, processes, and the plant are heavily regulated. As part of the … and a major industrial plant in a small town, management faced the need to cooperate with (critical) stakeholders.

Supply chain

There were no supply-chain pressures or initiatives from the raw material suppliers. However, on the customer side, there were in some cases strong preferences to deliver environmentally sound products.

Implementation

Companies, in particular SMEs, cannot devote a large effort to an academic analysis of what type of tool could be used for a particular problem. In addition, they will not use all of the EM tools. Most of them will try to establish one common approach to achieve sound EM. Both LCA and EMSs are valuable tools for improving the environmental performance of organisations. Due to the company-oriented, procedural approach of EMS and the product-oriented, analytical concept of LCA, they are methodologically not compatible, even if at first sight similar system elements like the input—output analysis of material and energy flows are compared. The integration of the analytical EMS element corporate ecobalance (CEB) into LCA might be theoretically possible, but practical relevance is questionable due to different system boundaries and different reference units, parameters, and data. A promising solution might be a company or situation-dependent combination of LCA and EMS in an ideal sense in an orthogonal manner. A sensible and comprehensive combination of complementary elements might increase the efficiency of EM efforts towards ecological and economical sustainability.

The company began their LCA activities on a project basis. As a starting point, the main interface between LCA and EMS, which is obviously the evaluation of the potential environmental impacts associated with the respective economic activities, was analysed. From a practical and economical point of view, it is desirable that CEB data could be used for LCAs, that is, LCAs could be compiled by aggregating several 'gate to gate' energy and material balances of companies and vice versa. At first glance, there is no reason why this should not be feasible. However, in many LCAs and CEBs, the parameters and data used are somewhat different. Specifically, the parameters that are relevant for an LCA are flows that cross the border between technosphere and ecosphere. They are referred to as 'elementary flows' and 'product flows'. As a consequence of the life-cycle concept, the elementary flows consist of resources on the input side and emissions on the output side only. All intermediate products are followed back to their origin, that is, the intermediate flows are completely within the technosphere and therefore are inputs and outputs of processes but not of the final life-cycle inventory (LCI). In EMS, the flows that enter and leave an organisation are relevant. Therefore, intermediates are found in the input—output scheme of CEBs. CEBs require data on the full magnitude of the processes.

Another difference in the parameters studied between LCAs and CEBs is the stock. In a classical LCA, all processes are assumed to operate at a steady-state level and at regular operation conditions. Only the allocated net inputs and outputs are used to calculate the LCI. In a CEB, the stocks of materials and the consumption due to nonregular operations are considered. Because the storage of chemicals has considerable environmental risk potential, CEBs deliver more

information on that aspect than do LCAs. In the case study of the company, it was revealed that, apart from the parameters themselves, the data to quantify the parameters have a different type, too. This can be demonstrated by Figure 4-1 and Figure 4-2, which show CEB and LCA results for the primary energy demand of the production (compounding) of 1 kg of paint.

As mentioned earlier, CEB and LCA theoretically answer different questions. However, the studied paint producer used the respective information for the same purpose of optimising the production process.

The LCA results for 2 types of paint (LCA paint A, LCA paint B) were compiled according to ISO 14040 methodology, including intermediate and raw material production (ISO 1997). For the CEB results, 1 kg paint was employed as an EMS indicator. This measures the specific energy demand per kg paint by dividing the energy demand of the CEB by the amount of paint produced. All the raw data are from the same company.

Figure 4-1 examines the results of the compounding step in detail. The primary energy demand for compounding according to the CEB is higher than both of the LCA results. This can be explained by the different data types used to quantify the respective parameters. For the LCAs, paint-specific energy data of steady-state operation are used. The CEB data represent the overall energy demand. The main difference is the energy consumption for business sectors like administration or research and development (R&D) or room heating, both of which are included in the CEB but not accounted for in an LCA. To neglect these data within an LCA is a convention,

Appendix 7 - Identification of certain factors groups

Here is an example of selected parts of the extracted text into the eight factor groups based on their commonality. The text relates to the extracted text in the previous appendix.

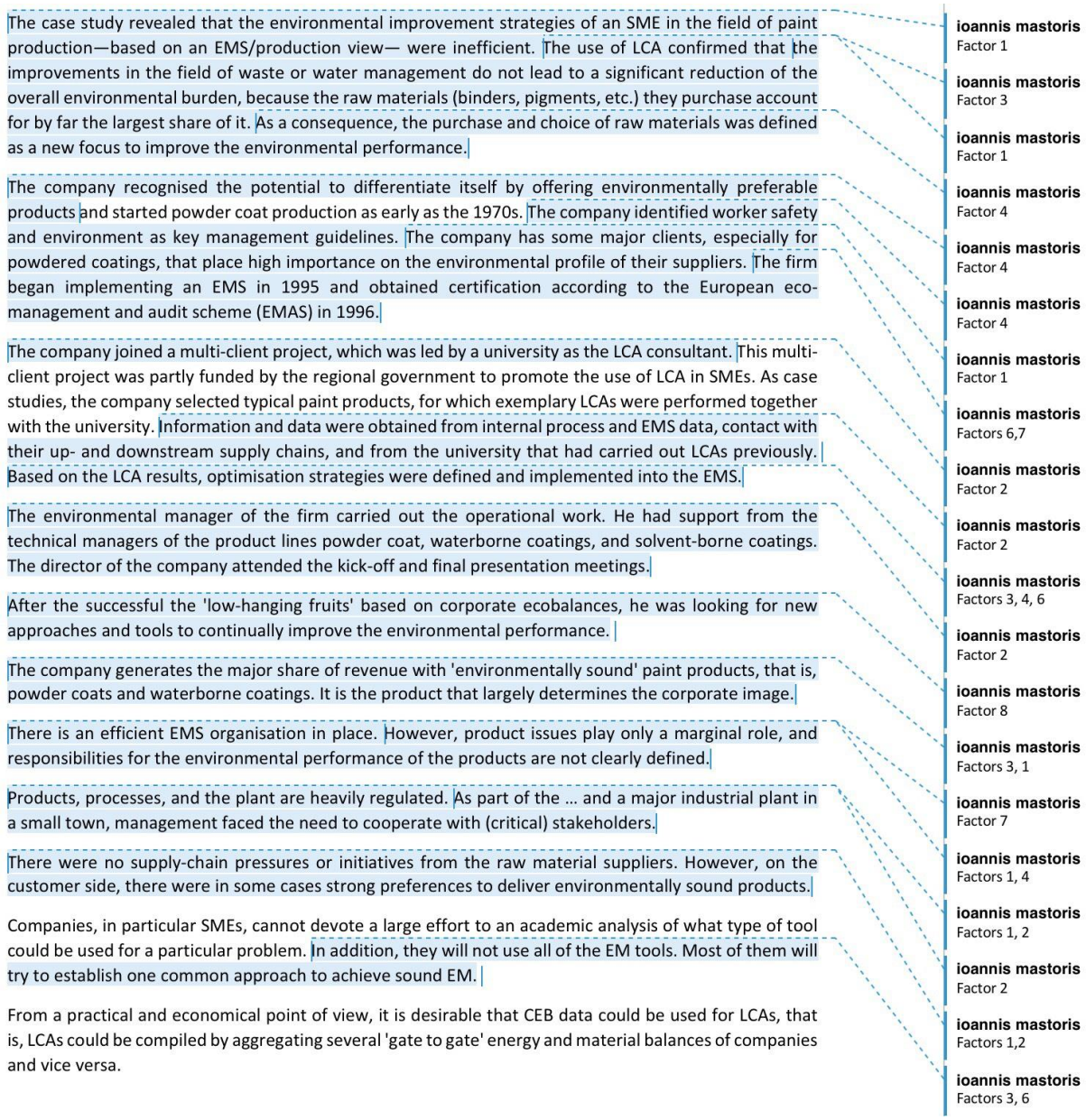

Figure 69. Selected parts of extracted text of appendix 6 into the eight factor groups based on their commonality.

Appendix 8 – Analysis examples

In this section, some examples of detailed analyses are presented.

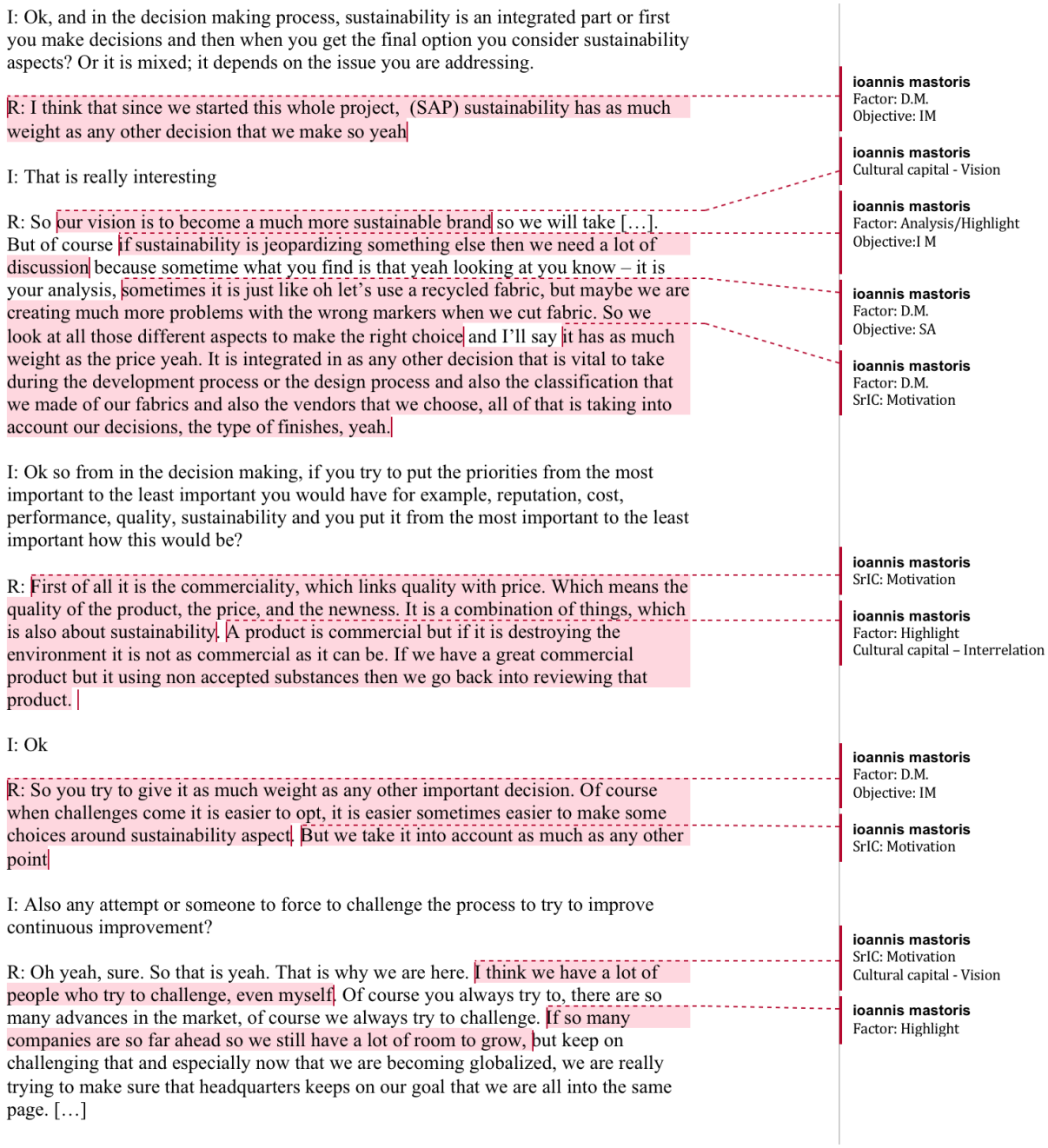

Figure 70. Analysis part of a semi-structured interview of case A.

Figure 71. Analysis part (extracted text) of a Focus group of case A.

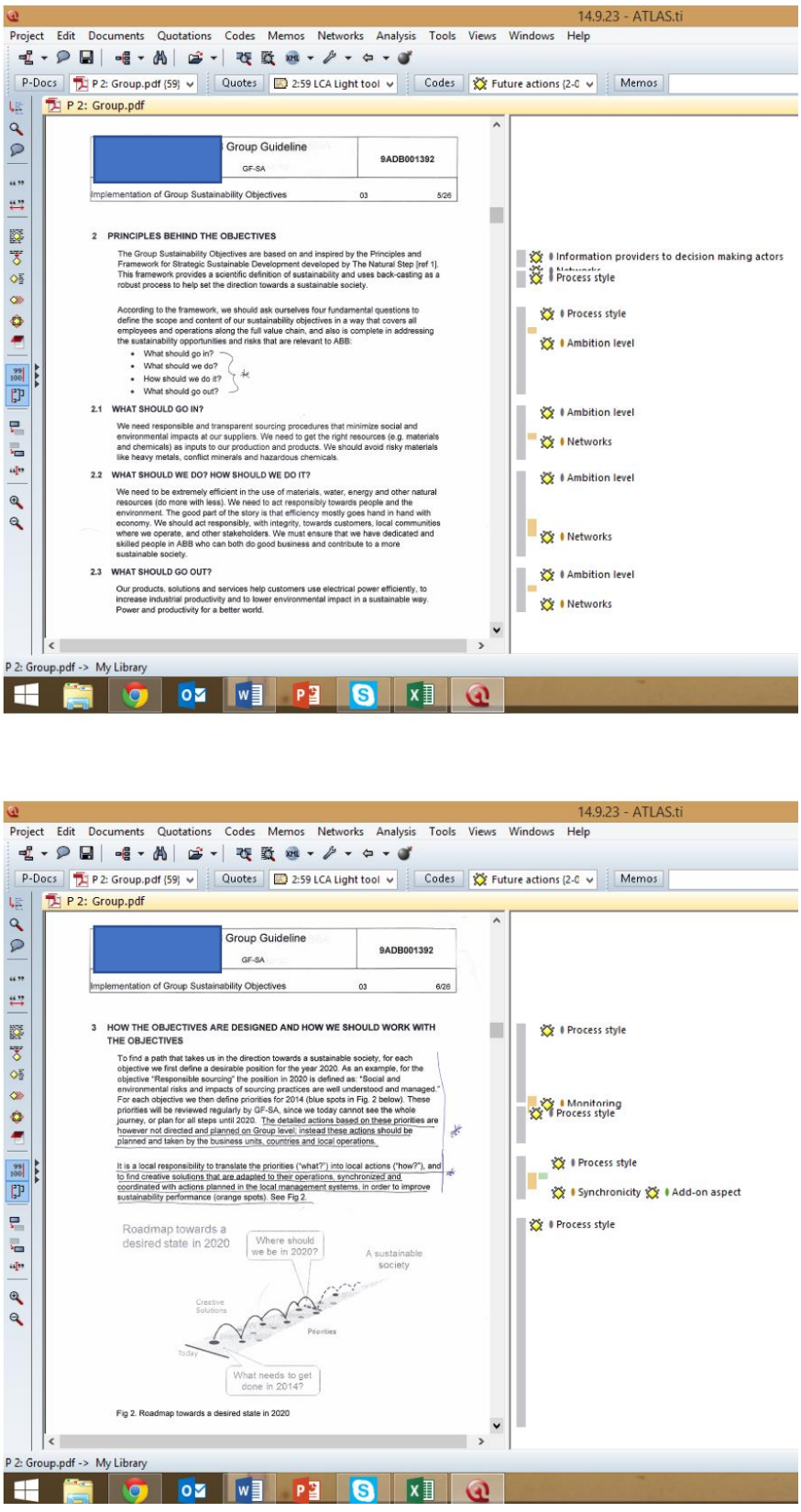

Figure 72. Corporate document analysis of Case B.

Knowledge base

Approach

IM: And now about the goal setting process. So what was the sequence of processing of processes of deciding the nine ambitions? The different steps, how you started and you end up with these?

AN: Well, I mean we have had environmental objective were first introduced some ten, fifteen years ago. Then that was broadened into sustainability objectives maybe ten years ago. And then, we had those objectives for some time, they shifted a little, but there was, not everyone was happy with the way we had the objectives before because they were regarded as too inward looking for the sustainability function and that they weren't actionable out in the organization. So that's why we have the task to look into new objectives, and the ambition was that these objectives should be, cover all of [redacted], not just the sustainability function. They should be actionable at the local business unit level. People should feel out in the organization, yes this is relevant to us, yes we can take action on these objectives. So that was the background.

LS: So no further sustainability function.

Human/Group

AN: Well, I have a Master of Science degree in Engineering and Physics and a Doctors degree in material science and solid state physics and I started here many years ago in 1995 and then I started working on sustainability issues in 1999 related to climate change. And from 1999 it has been learning by doing.

LS: Ok, well I worked with Environmental institute since 1990 so I learned the work. I got a Masters in Chemical Engineering that is my background in Chemistry and I also made research, I mean to Licentiate degree (PhD) in Industrial economics in Chemistry and Economics. 24 years I have been working on these issues.

Culture

LS: Here because I think it is quite interesting, this is CEO message in our last sustainability performance report (2013) because there you have,…

IM: And now about the goal setting process. So what was the sequence of processing of processes of deciding the nine ambitions? The different steps, how you started and you end up with these?

AN: Well, I mean we have had environmental objective were first introduced some ten, fifteen years ago. Then that was broadened into sustainability objectives maybe ten years ago. And then, we had those objectives for some time, they shifted a little, but there was, not everyone was happy with the way we had the objectives before because they were regarded as too inward looking for the sustainability function and that they weren't actionable out in

Figure 73. Part of IC in action extracted quotes of a Semi-structured group interview of case B.

Report: 42 quotation(s) for 1 code

HU: 14.9.23
File: [C:\Users\Ioannis\14.9.23.hpr7]
Edited by: Super
Date/Time: 2015-11-27 11:35:58

Mode: quotation list names and references

Quotation-Filter: All

Collective knowledge

P 5: 14.04.29 LSO Cables.docx - 5:15 [get tips from each other and w..] (101:101) (Super)
Codes: [Collective knowledge - Family: Information]
No memos

get tips from each other and what kind of actions, certain goals could have

P 6: 14.04.29 ROBOTICS LSO.docx - 6:45 [AR: but at least there is noth..] (135:135) (Super)
Codes: [Collective knowledge - Family: Information] [Teamwork+alignment - Family: Organisational]
No memos

AR: but at least there is nothing that, our freight manager, he didn't know anything about it.

P 6: 14.04.29 ROBOTICS LSO.docx - 6:46 [AR: But I think, they have not..] (139:139) (Super)
Codes: [Agility - Family: Human] [Collective knowledge - Family: Information]
No memos

AR: But I think, they have not reached the organization.

P 6: 14.04.29 ROBOTICS LSO.docx - 6:50 [So as a person who, were in ch..] (141:141) (Super)
Codes: [Collective knowledge - Family: Information] [Teamwork+alignment - Family: Organisational]
No memos

So as a person who, were in charge of them today is Caroline. But we also developed a guideline for calculating carbon dioxide emission that I sent to you. But that was not approved because supply management in Zurich did not want us to release it.

P 6: 14.04.29 ROBOTICS LSO.docx - 6:51 [Then it was, I think made as a..] (141:141) (Super)
Codes: [Collective knowledge - Family: Information]
No memos

Then it was, I think made as a Swedish instruction by Caroline but you have it on your computer now. But I also sent you this, the template to calculate this, the calculating factors. And you can see, but that is aggregated for Sweden. So that was a total. So basically you can see the carbon dioxide patern from Sweden is 70% is goods transport, 20 are operations and 10 is business travel. So 70% is logistics and 75% of that is air freight. So 70% and 75, so 3 or 4 quarter is air freight. So we have done a lot of work. But I am not connected to this today. I just tell the history. But today Caroline is in charge of this

Figure 74. Part of the Collective knowledge SrIC-factor quotes extraction of case B.

Appendix 9 – Sustainability-related processes at Company B

In company B the sustainability processes take place at three stages, the steps of each stage are described below.

Developing -> focused on strategising

The GMSG has appointed two members of staff (one of them was the project partner) to develop global sustainability targets that company B should achieve by a certain date. The GMSG team followed a six-step process that lasted for several months, including:

1. The team started with ground work, they analysed the available sustainability data of the company, analysed what and how other companies did and conducted a literature review. Using obtained knowledge, team members developed an early version of the paper that was gradually updated along the process.
2. During the second step, the team consulted people from SG, who worked at the corporate (GMSG) and business unit (CMSG) levels.
3. During the next step, the team involved a group of experienced sustainability consultants to seek their feedback and advice regarding the following steps.
4. At this point, the team had more than thirty consultations at the corporate and business unit level in the SG and non-SG parts of the organisation.
5. The team had developed a list of targets, and they sought the approval and suggestions of a small number of business unit leaders.
6. The team integrated suggested changes and delivered the list of sustainability targets.

Deciding -> focused on decision-making

The decision-making part was a complicated process that involved nine steps:

1. The CMSG team received the target list from the Geographic area country management requesting to develop country level sustainability targets for the next year.
2. The CMSG team filtered the Global targets and chose the targets that applied to the team when the context of the country was considered. This helped to focus their attention only on the targets that mattered.

3. The CMSG team contacted the local group functions (LGs) and asked if they already worked on some of these targets, and requested their advice on the plausibility of certain targets that were aligned with each LGs focus.
4. Considering the input from the previous step, CMSG developed a set of draft targets and passed it to the local division sustainability officers (LDSM), one for each division plus one for LGs, who discussed the relevance and feasibility of targets for each division.
5. CMSG asked each LDSM in collaboration with the LSMs to contact the LBUs and LGs managers and discuss
    a. the targets that apply in their LBU/LG,
    b. the impact of targets (how to implement them, what resources were needed, etc.),
    c. moreover, come up with targets and implementation plan for each target.
6. The list of global targets included indications on accountable and responsible personnel for each target. Usually, LBU/LG manager and manager/officer were assigned as accountable and responsible members of the team depending on the specific area of each target. The local sustainability managers (LSM) in collaboration with the responsible personnel developed a draft target and an implementation plan for each target.
7. The LSM communicated a draft set of targets and implementation plans to CMSG. The CMSG team reviewed the draft and made a decision if it was ambitious enough. In case the draft required further work, the CMSG team sent the draft back to the LSM to update it in collaboration with the responsible and accountable personnel for each target that needed improvement. This process could have happened several times until CMSG was satisfied with the presented list of targets.
8. After CMSG's approval of the target list had received from LBUs and LGs, CMSG developed a document with the draft targets for the country for the given year and presented it to the Geographic area country management.
9. The Geographic area country management reviewed the final plan and made amendments if needed and published internally the targets for the given year.

Implementing -> focused on sustaining

The implementation stage was much less complex.

1. With the assistance of the LSM, the member of the team responsible for each target implemented the plan in accordance with a target list.
2. The LDSM provided quarterly reports regarding the implementation status to CMSG.
3. The CMSG analysed the implementation data and based on the performance of each LBU/LG, CMSG assigned a score to every unit; that was later communicated to the Geographic area country management.
4. The Geographic area country management reported to the regional level while regional level informed the relevant GFs and Executive Committee.

Appendix 10 - Suggestions

The results of the interviews' analysis helped the researcher to develop a set of interventions that were suggested to GMSG team; many of them were adopted, while the rest were kept in the drawer until their time will come.

LDSM and LSMs roles mapping; variables to explore:

- Percentage of their time for each role.
- Tasks to deliver.
- Analysis of how they spend their time. Identify bottlenecks, work that could be shared, etc.
- Resources available. Identify information and template needs.
- Education. Identify training needs.

Develop a collective knowledge infrastructure using common denominator factors framework to classify information. The classification according to product, process, property, place, people/business, environmental, social/value chain stages might be useful.

- Collect all available tools and information, classify and make them available to all SG people.
- Start a pilot with certain tools available.

Use online forums for SG people, so they will be able to discuss, ask for advice, share common work and ideas, create tools and templates. Allow people to interact with different areas, same or different divisions.

- Start a pilot with some countries/ divisions.

The business case for sustainability paradigms/ templates.

- Research on the motives of BUs and GFs.
- Start a pilot with a function and a business unit.

Identify cases of sustainability excellence or high level of performance and good cases of SG interaction with the organisation, analyse them and create a code of conduct of SG with non-SG part of the organisation.

Leadership framework and training.

- Define leadership tasks for each level.
- Use a form of the capabilities/tactics matrix towards certain goals.
- Develop a regional or divisional role on sustainability leadership; start with a pilot.

Furthermore, the researcher provided an LCM guide described in Table 54 that was informed by the SrIC analysis and described the conductivity of SG and non-SG members of the team towards sustainability issues.

Table 54. Proposed LCM guide.

Factors	Organisational levels		
	Organisation level	SG (guide)	Non-SG (apply)
Leading	Need to create an organisational culture that supports the development of sustainability aspects in the corporation. This can be achieved by creating common sustainability values and vision. Also, making the connection between good corporate sustainability performance and business benefits (i.e. cost reduction, reputation, legislation, fewer interest rates).	Create an organisational culture by supporting the development of sustainability aspects in the area of responsibility. This implies guiding/ inspiring the sustainability employees for which they are responsible/ accountable and the non-sustainability employees who have to be to influence.	With the support of the sustainability function employees to integrate the sustainability aspects applied in the area of responsibility and to influence employees for whom they are responsible/ accountable. This involves putting the sustainability aspects in the typical business agenda & encouraging to take an action.
Collaborating	The sustainability aspects apply to every part of the organisation and its value chain. To realise the sustainability vision of the corporation many parts of the organisation have to collaborate with other parts of the organisation or the value chain.	Involve the right collaborators in the process by providing incentives for participants to follow.	Collaborate with sustainability function employees (e.g. involve in LBU meetings). Also, collaborate with internal and external actors on sustainability aspects (e.g., collaborate with R&D to change the recipe, collaborate with OPEX to improve processes).
Analysing	Identifying the condition of certain sustainability aspects information/ available knowledge must be considered before planning any action.	Monitor the performance of sustainability aspects, analyse data, identify knowledge elsewhere, identify challenging decisions/actions, so the employees who need to take action are informed.	Ask/ provide information/data needed. Analyse the impact of certain actions at the BU/ LBU/ LG.
Strategy making	Strategy making happens at different levels of the organisation. It starts with the corporate vision on sustainability, which is the platform strategy and its lower levels are used to develop the seasonal strategies for each country that relates to each company/site individual seasonal strategy to integrate sustainability aspects. Each country/ company/ site has different challenges to manage (sustainability aspect wise and ambition-wise).	Support LBUs and LGs in the development of actionable seasonal plans that are aligned to the context of each LBU.	Enable and prioritise actions by considering sustainability employees' input for the seasonal plan and the impact of certain actions at the BU/ LBU/ LG.
Decision-making	Relates to the action plans to be decided at a local level to realise the seasonal strategy of the BU/ LBU/ LG. Different functions have different challenges to meet to put their piece in the country's HSE Plan puzzle.	Support decision-making with the appropriate information and knowledge on sustainability aspects considering the context of the application.	Same as above.
Implementing	Refers to the realisation of action plans to enhance the state of sustainability aspects.	Support implementation with the appropriate information and knowledge that might be needed.	Make actions decided upon the part of the routine. Encourage action.

Sustaining	Refers to the endurance/ resilience and monitoring of action plans performance.	Sustainability function – individual employee (guide)	Non-sustainability function - individual employee (apply)
Developing – Organisational learning	Refers to a continuous improvement of the conditions of sustainability aspects and development of seasonal strategies through time.	Create an organisational culture by supporting the development of sustainability aspects in the area of responsibility. This implies guiding/ inspiring the sustainability employees for whom they are responsible/ accountable and the non-sustainability employees who have to be influenced?.	With the support of the sustainability function employees try to integrate the sustainability aspects applied in the area of responsibility and influence employees for which they are responsible/ accountable to follow. This implies putting the sustainability aspects in the typical business agenda and encouraging to take the action.

Appendix 11 – Quality and rigour

Table 55. Quality and rigour in action research applicability.

Action research quality and rigour factors (Reason, 2006)		Applicability in this study
Quality	Is the action research explicit in developing a praxis of relational participation? In other words, how well does the action research reflect the cooperation between the action researcher and the members of the organisation?	Figures 17 and 49 describe the interaction with the organisations.
	Is action research guided by a reflexive concern for practical outcomes? Is the action project governed by constant and iterative reflection as part of the process of organisational change or improvement?	There were two dimensions of iterative reflection: (1) longitudinal research of this project starting from the analysis and progressively ending with the continuous improvement part; (2) interaction and role of the participants of two cases in the longitudinal development.
	Does action research include a plurality of knowing which ensures conceptual-theoretical integrity, extends our ways of knowing and has a methodological appropriateness? Action research is inclusive of practical, propositional, presentational and experiential knowing and so as a methodology is appropriate to furthering knowledge on different levels.	The conducted action research projects increased knowledge on corporate sustainability management at practical, propositional and experiential knowing.
	Does action research engage in significant work? The significance of the project is an important quality in action research.	Both conducted projects were very important for sustainability groups and this research as a whole made an impact on the enhancement of sustainability aspects integration.
	Does the action research result in new and enduring infrastructures? In other words, does sustainable change come out of the project?	The interventions suggested in case A resulted in new infrastructures, whereas in case B the organisation was expected to develop them.
Rigor	How you engaged in the steps of multiple and repetitious action research cycles (how constructing, planning, taking action and evaluating were done) and how these were recorded to reflect that they are a true representation of what was studied.	The adoption of the diamond model of engaged scholarship (Figure 8) and description of its applicability in (Figure 2) covering this rigour factor is described in section 3.4. on research design delivery.
	How you challenged and tested your assumptions and interpretations of what was happening continuously through the project using content, process and premise reflection so that your familiarity with and closeness to the issues are exposed to critique.	Both cases were based on the initial ideas (for each case) of the researcher, and the project interactions helped to develop these ideas.
	How you accessed different views of what was happening which probably produced both confirming and contradictory interpretations.	The participants of sustainability groups expressed different ideas from the rest of the organisation. The researcher compared their views with their SrIC-in action performance.
	How your interpretations are grounded in scholarly theory, rigorously applied, and how project outcomes are challenged, supported or disconfirmed regarding the theories underpinning those interpretations and judgements.	Sections 9.4 and 9.5 answers this question.